PRODUCT ENGINEERING

KENNETH H. CONDIT
Editor

DECEMBER, 1933

MCGRAW-HILL PUBLISHING CO., INC. VOLUME FOUR, NUMBER TWELVE

There is No Magic in ECPD

EVERY engineer is in sympathy with the purpose of the Engineers' Council for Professional Development (ECPD), namely, "the enhancement of the professional engineer." Never before has there been such a concerted effort to further the professional standing of engineers as is embodied in this group. Not only is this Council authorized by the six leading engineering societies, but also by the National Council of State Boards of Engineering Examiners. Among its officers and members are the outstanding engineers of our country.

There will be differences of opinion over the various qualifications and requirements for professional standing as approved by ECPD. Apparently even the members of the committee were not in entire agreement. Some engineers will consider the requirements to be not high enough, but the standards can, and undoubtedly will, be raised as the profession receives better recognition. Requirements appreciably lower than those approved would be too low to command the respect of either the members of the profession or the lay public. Differences of opinion about the approved required qualifications should not deter progressive engineers from endorsing the actions of ECPD as set forth in its report.

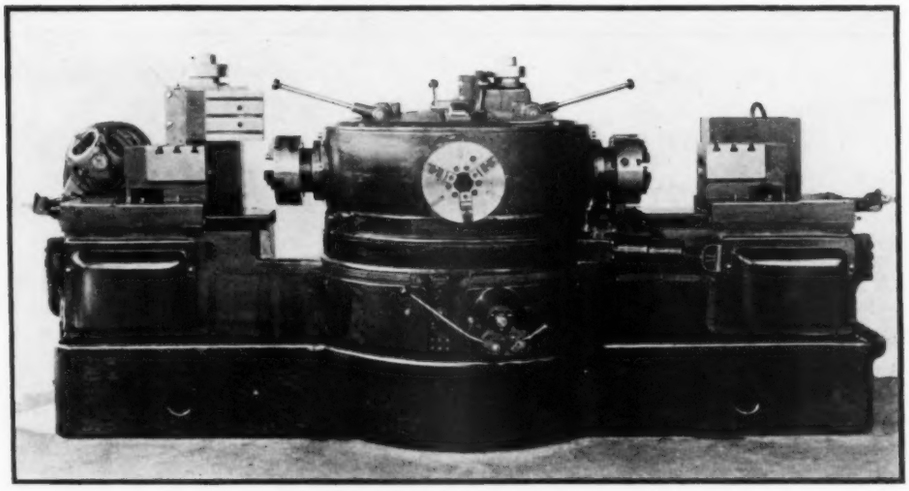
Active opposition to the program of the ECPD can only come from those engineers whose ambitions or attainments are so low that they cannot hope to come up to even the lowest reasonable professional requirements that may be established. This group comprises such a small minority that it will have no noticeable influence.

Any program looking toward proper recognition for the engineering profession is not likely to be hampered by objectors. But the failure of engineers individually to show a proper mental attitude toward the dignity of their profession would defeat any attempts to elevate the profession. ECPD, or any other organized body, can do nothing more than make rules and recommendations for the guidance of the profession. Even if such rules partake of the nature of laws, as by incorporation in state codes governing the licensing of professional engineers, they will have only a limited effect unless a large majority of engineers give their individual support to the intent of the legislation. What will be accomplished by ECPD cannot be more than the result of the sum total of the individual efforts.

Specifically, individual effort to elevate the profession includes participation in the solution of professional problems and adherence to a high code of ethics. But, of far greater importance, it requires that every engineer must at all times exhibit by acts and conversation a wholesome respect for his profession. Such an attitude should prevail when dealing with other engineers and with lay people as well. Self-respect breeds respect. You must know your worth before others can recognize it.

Hydraulic
VERSUS
Mechanical Feed—I

A. L. DeLEEUW
Consulting Engineer, Plainfield, N. J.



Goss and DeLeeuw chucking machine with cam feeds and spindle speeds changed by independent pick-off gears

HYDRAULIC feed has been long enough in practice to make it possible to look at it unbiasedly. Like most new things, it has had its adherents and its opponents. The first looked mainly at the good side, the others mainly at the reverse. That hydraulic feed is becoming more and more common shows that its bad points are not enough to condemn it, and the fact that some of the one-time enthusiasts have turned their backs on it proves that it is not altogether good—just like everything else. There is now enough knowledge and experience on hand to make a survey and pass fair judgment.

To pass such judgment one should compare hydraulic feed with the older means for obtaining the desired results, in other words, with mechanical feed. If faults are found with either, but means for correcting them can be visioned, though they are as yet not used, such means should be considered as well as existing methods and mechanisms. It will be found that either one of the two has its place, that neither one has all the virtues or faults, and that the best all-around results will be obtained when each one is used where it has the better of the comparison. It may also be found that, at times, a combination of the two is better than either one alone.

It is generally believed that hydraulic feed produces an even, smooth motion, that it can be made for a wide range of feeds without complication, that it is adjustable as to amount by infinitesimal increments, and that it requires a minimum of mechanism, and, consequently, a minimum of maintenance. It cannot be denied that, in theory at least, it has all these advantages. That it does not work out in practice with 100 per cent results has turned some people away from it.

The first claim, that the hydraulic feed gives a uniform and smooth motion is substantially correct. It does so under almost all circumstances, and, when it does not, the cause of the misbehavior is usually easily found and corrected. However, there are cases when the repair man is puzzled for many a day. The most common cause of irregularity is the presence of too much air in the oil. It should not have been there in the first place, and, in the second place, the condition is easily cured. There are, occasionally, other cases, especially when the arrangement calls for a wide range of feeds. Everything may go well with the higher amounts, but when the smallest amounts are called for, trouble may arise in the form of irregular or halting feed. A single grain of dirt or of any other foreign material lodged in the throttled-down opening of a valve may be enough to cause this trouble. However, as a whole it may be said that this claim of uniform and smooth motion for the hydraulic feed is substantiated in practice.

In theory, a screw gives as even or uniform a motion as can be obtained by hydraulic means, but as a matter of fact this is not so, and is less and less so with increasing pressure or length of stroke. There is, of

necessity, some lost motion between screw and nut. There is, further, some wind-up in the screw, and this increases with length and pressure. If the required feed pressure be absolutely the same all along the stroke, the wind-up and lost motion have no bad effect, but such ideal conditions should not be expected in ordinary shop practice. Furthermore, even if all conditions are as good as they can be so far as uniformity of pressure and perfection of the screw are concerned, the gears which lead up to the screw may not give the screw a perfectly even motion.

It may be said, therefore, that where absolute uniformity of feed is required, the hydraulic feed has the better of the argument. On the other hand, such a perfectly uniform feed is not often required. Ordinary drilling, reaming, boring or turning do not call for such perfection of uniformity, and as to milling, one claim made for one of the well-known milling machines is that the amount of feed is automatically increased when the amount of metal to be removed becomes less. The last mentioned condition prevails with the particular design of this machine, but is not to be expected with any and every design of hydraulic feed arrangement. The most conspicuous advantage of this uniformity of the rate of feed travel is to be found in the drilling machine where it prevents the sudden breaking through of the drill near the end of the hole.

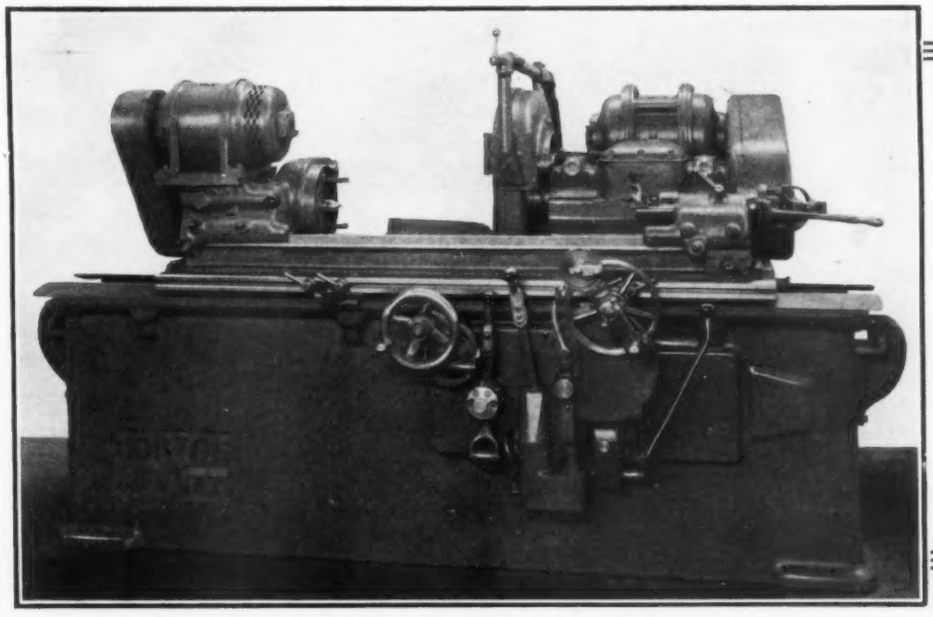
Speaking of an even motion and a smooth motion, there are really two different things meant by the terms. Evenness of feed in a machine tool may mean that the amount of feed travel per unit of time is constant, or it may mean that there is a uniform amount of feed per revolution of the spindle. Then, again, it may mean that the amount of feed per minute does not change so long as the same setting of the machine is retained.

In the first case, that is when there is a constant amount of feed per minute, there may be a variable amount per revolution of the spindle. Perfect uniformity of spindle speed is not to be expected with a changing amount of metal to be removed. Besides, there are the unavoidable variations in the speed of the driving motor. In such a case, there is no real uniformity of the feed so far as the work is concerned.

As to uniformity of feed from hour to hour or from day to day, this is a thing to be wished for but not to be obtained by hydraulic feed without a struggle, for it depends to a large extent on the condition of the oil, and this condition changes with the temperature of the shop and with the length of time during which the oil has been in continuous use. If the amount of oil in the reservoir is large as compared to the amount used per minute, the rise in temperature will be probably insignificant. But in the various installations which have come under the observation of the writer, this has not been the case, and there was a considerable rise of temperature after a morning's or afternoon's work. The effect of this rise on the amount of feed is very marked. In many instances this trouble can be eliminated. Where there are a number of machines with hydraulic feed, some or all of them might be grouped and a common oil reservoir used. Such a reservoir could be placed where it would be out of the way and could be of large enough size so that there would be no appreciable temperature rise. By using a cooling unit in the common reservoir, it would not need to be so large. Or when each machine has its own reservoir, a cooling unit could be used in each of the individual reservoirs.

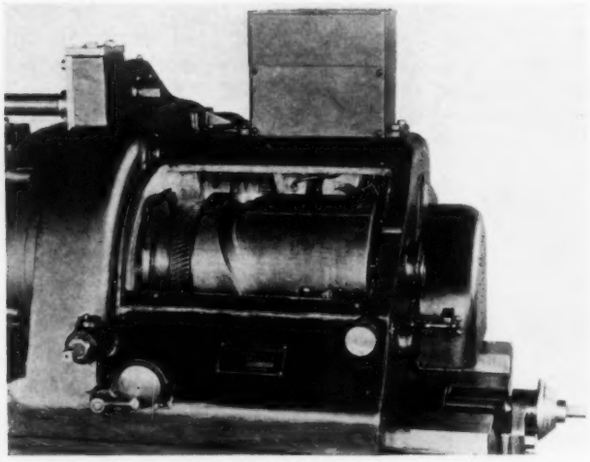
The reason why a change in the feed rate is not always observed is because most operations in the shop are of relatively short duration and a portion of the time is occupied with such things as loading and unloading the work. Merely comparing the times of two operations, one of which is performed at the beginning of the day and the other at the end, would not tell much, because the amount of possible difference is small, unless there should be some operation during which the feed was acting for a considerable time. Making observations of an hour's duration will show a quite noticeable difference.

Though the evenness of the hydraulic feed may be criticized, at least in most actual cases, the smoothness is a real advantage. That there are conditions which mar this effect has been mentioned. Most of these can

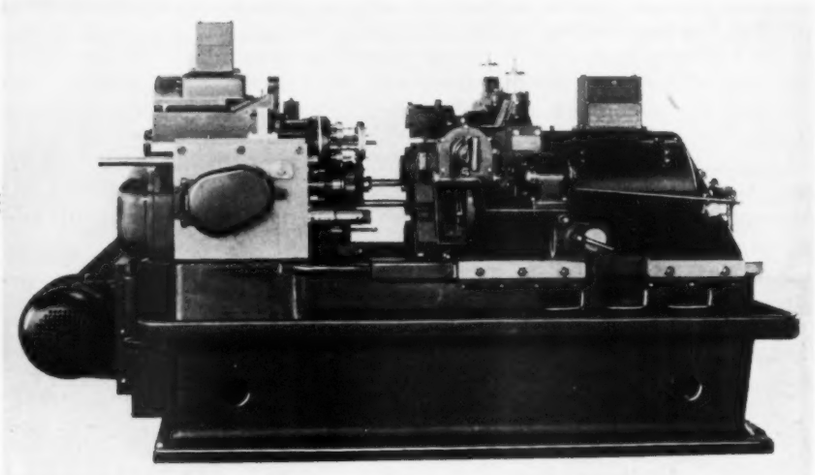


Cams are not suitable for a long stroke or feed travel. On the other hand, there is practically no limit to the travel that can be obtained hydraulically. This Norton 10x36 cylindrical grinder has a hydraulic table traverse. The wheel-head is also fed hydraulically

be avoided; some are of a temporary nature only, and others are the result of inferior design. Air can be removed before the oil is introduced into the system and can be kept out of it. Means for these purposes are now being employed in the better worked-out designs. The system should be well protected against the entrance of foreign substances, and, should something enter by accident and trouble result as a consequence, this should be considered as other troubles are—as annoyances, without which life would be too perfect. There are sometimes unexpected troubles with mechanical feeds too. The thing to remember is that the smoothness inherent in the hydraulic feed prolongs the life of the tools because it reduces the amount of vibration caused by the cut. This feature is of special advantage when carbide tools are used.



For relatively short travel, the barrel-type cam has many advantages. This solid track split-barrel cam operates the main slide feed of the Goss and DeLeeuw tool-revolving chucking machine shown below



When a number of feeding elements must retain a definite relationship, a mechanical feed is usually better. This four-spindle tool-revolving 8½x8 chucking machine built by the Goss and DeLeeuw Machine Company illustrates the point

The claim that hydraulic feed mechanism permits the increase of the feed by infinitesimal steps is absolutely true in theory. The graph describing the succession of feeds is a continuous curve. The graph of a friction feed would show the same characteristics. The graphs for other mechanical feeds would show a number of steps which may be more or less close together. Theoretically, there is no limit as to the closeness of these steps, but the curve must always be a broken line.

It would seem at a first glance that the continuous curve must be of material advantage in practice, but a closer examination shows that it is little, if any, better than the curve obtainable with mechanical feed. The high expectations in this respect are probably based on comparisons with old practice rather than on the newer possibilities.

In late years many machines have been designed for mass production only, or, at least, for mass production mainly. In such machines productivity while running is the important feature. The fact that it may take a little longer to set them up is not of much importance. If a machine is used year after year on the same job the set-up time is of no importance. If it is used on different pieces but all of the same type or all requiring the same kind of operations, and always in fair-sized lots, the easy set-up is of some but not of much importance. What is of importance is to have feeds and speeds as nearly correct as they can be made. In such machines pick-off gears are used for the feed unless hydraulic feed should have been provided.

What advantage does the hydraulic feed have over a mechanical arrangement if the object is to get the amount of feed as nearly as possible correct for the job on hand?

Using pick-off gears, one can make the steps between feeds as small as one desires, but the curve can never be continuous. There is a practical limit, too, as to the smallness of the steps. If one were to use a pair of pick-off gears of a thousand teeth each there would be an extremely small step between these gears and the ratio of a pair of gears of 1001 and 999 teeth respectively. The difference would be one-fifth of one per cent. On the other hand, the arrangement would be entirely impractical. However, it is possible to get quite small steps with gears of reasonable size. With a center distance of 60 teeth we would get the following:

60-60 ..... ratio 1.000
59-61 ..... ratio 1.034
58-62 ..... ratio 1.068
etc.
42-78 ..... ratio 1.857
41-79 ..... ratio 1.927
40-80 ..... ratio 2.000

The maximum difference between two successive steps is a little over 3½ per cent. With a smaller number

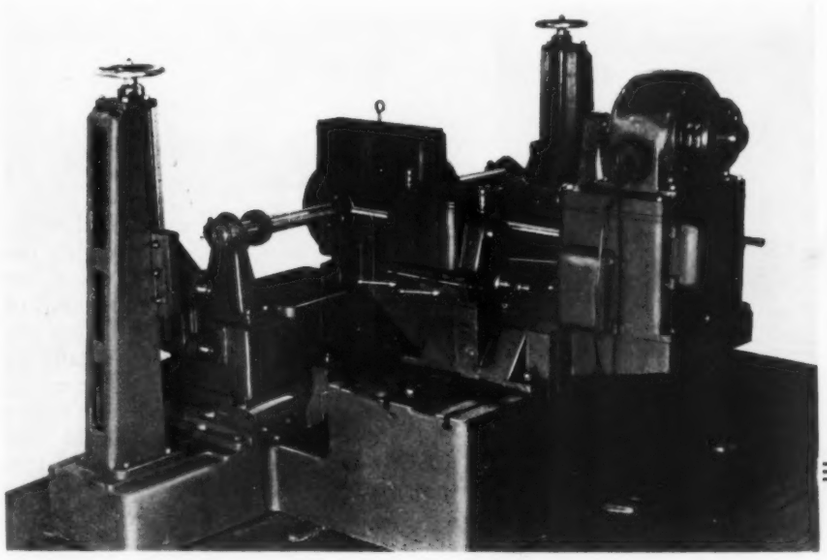
of teeth between centers this percentage would be larger, and with a larger number of teeth it would be smaller. The total range is four to one. If the smallest gear has less than the number of teeth selected here the range would be greater. The greatest possible range with the 60-60 combination would be twenty-five to one, though this would hardly be practical. The smallest gear would then have to be of 20 teeth and the largest of 100. It might be practical to have the 20 teeth gear as driver, but not as the driven gear, so that the widest range would be less than twenty-five to one, perhaps twenty to one.

Nominally the hydraulic arrangement would give steps of less than $3\frac{1}{2}$ per cent, in fact, they would be called infinitesimal, but in reality it would be difficult to approach the mechanical arrangement in fineness of steps. In the first place there is no way to set the hydraulic feed to any definite amount, at least not within a reasonable percentage. There may be an indicator which tells what the amount of feed is, but this should be taken merely as an aid to bring the feed somewhere near the desired one, not as a positive statement of fact. In the second place, even if the indicator setting has been determined by experiment, or the trial and error method, the amount of the feed may vary from day to day to a greater extent than the steps possible by the use of pick-off gears. It is difficult to keep a record of the exact amount of feed used for a given job and still more difficult to duplicate the feed. It may be said, therefore, that this feature of infinitesimal steps has more value as a talking point than as a help to efficient production.

As to the wide range possible with the hydraulic feed, this also sounds somewhat better than it acts. However, this much may be said—it is much easier to obtain a reasonably wide range with hydraulic than with mechanical means. A range of twenty-five to one would be obtained easily, whereas, as we have seen, a single set of pick-off gears would not do for that range; a double set would be needed. A case has come to the attention of the writer where a range of a hundred and twenty to one was needed. A single hydraulic arrangement produced this range, but it gave trouble at the low end. Not always, but sometimes, and this is really worse than when the trouble is met all the time.

There are quite a number of different methods to obtain the range of hydraulic feeds. There is the adjustable displacement pump. Of whatever make such a pump may be, it depends on more or less shortening the stroke of a piston in a pump cylinder. In a pump of this kind there can never be a volumetric efficiency of 100 per cent. Besides, there is always some leakage, however small this may be. These factors have little influence when the feed is at or near its maximum. At the other end of the range these factors may account for a large per cent of difference, and when, by natural wear, the leakage has been increased, or when this happens by increased temperature of the oil, the feed at the lower end of the range may be extremely irregular and be something entirely different from what one expects to get.

In many designs the oil is circulated by a constant volume delivery pump. As the demand for oil in the feed system is not constant, a relief valve takes care of the unwanted oil. This makes the system mechanically inefficient and causes the oil to heat quite rapidly. The mechanical inefficiency is of not much importance, as the power requirements in a machine shop are but a small part of the total cost. However, the rapid heating of the oil is objectionable.



Cam grinding machine designed by the author and built by the American Machine & Foundry Company. One set of change gears determines the rate of feed for a given cam diameter. Any given feed can then be kept the same for different cam diameters by selecting pick-off gears in a second set of change gears through which the feed drives

In some systems the oil is delivered to the pressure member—the cylinder—by some metering device; in others pressure is maintained at the back of the piston and the outflow of this back-pressure oil is controlled by throttling an opening somewhere in the system. Whatever arrangement is used, more oil is put under pressure by the pump than is required by the cylinder and heating must result.

It is therefore the part of wisdom not to use the lowest part of the feed range. It is true that this reduces the range, but the control is improved. It may be said, therefore, that, though the hydraulic feed makes a wide range possible without any complications, this range is not as wide as is generally represented.

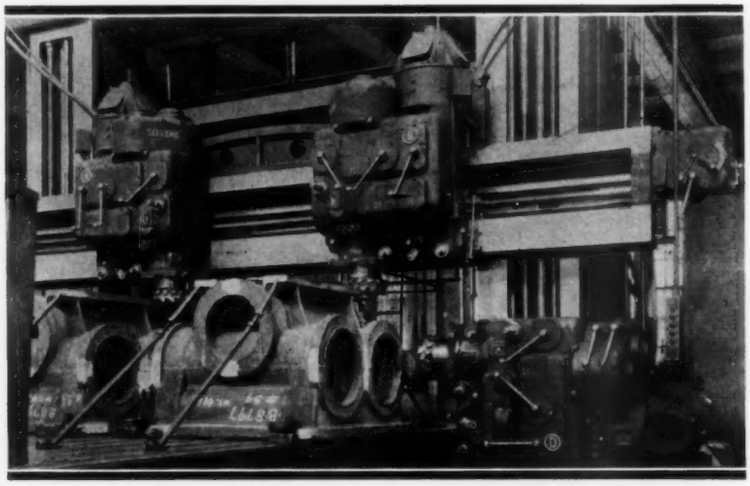
PRODUCT DEVELOPMENTS

▼ ▼ ▼

▸ Machine Tool Uses Ten Built-in Motors

Carrying out the idea of unit control for added flexibility, power, economy and ease in handling, a recently developed planer-type milling machine built by William Sellers & Company, Inc., has a total of ten motors. Each of four unit-type milling heads has a 15-hp. constant speed motor driving through hardened chrome-nickel steel spur gears supported on short shafts in antifriction bearings, eliminating the necessity for long spline shafts and bevel gears in the drive. Flange mounted motors are controlled by a push button providing a selection between the vertical and horizontal feed and traverse at the head. A self-contained lubricating system with pump and flow indicator is built in each head, which also carries stainless steel scales and a built-in dial indicator for quill travel.

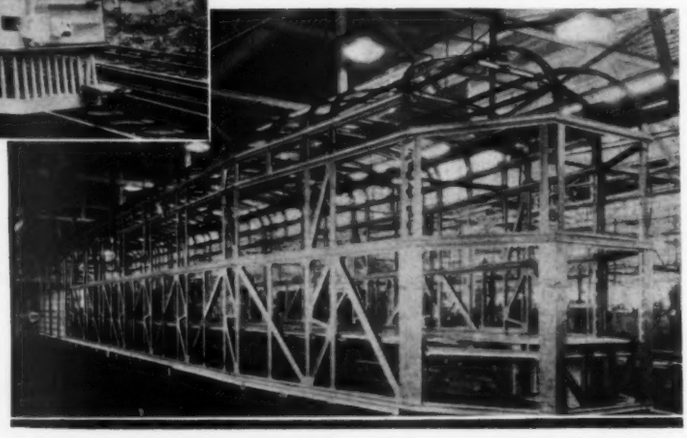
The use of more motors per machine simplifies the mechanical design by eliminating the necessity of carrying power to various parts by mechanical transmission. Thus, constant speed motors can be used where preferable and adjustable or multi-speed motors where there is advantage to be gained from variable speeds.



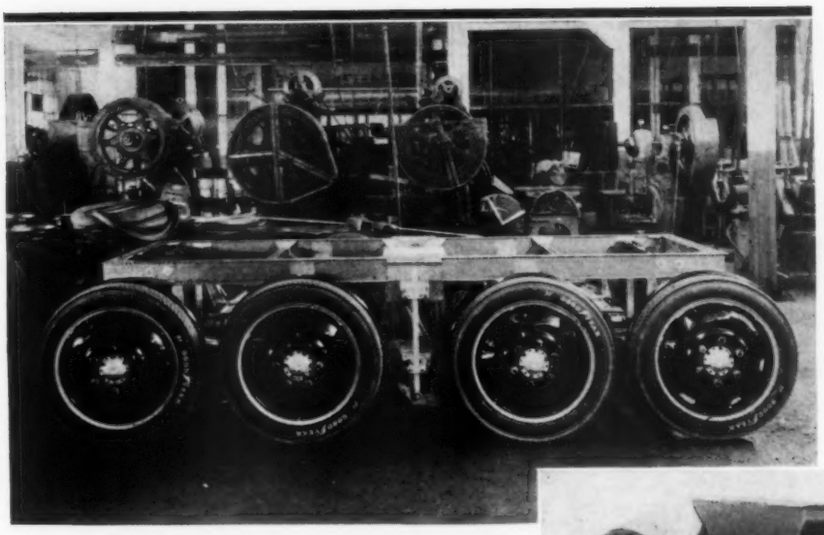
Ten built-in motors in this Sellers planer-type milling machine provide increased flexibility and convenience

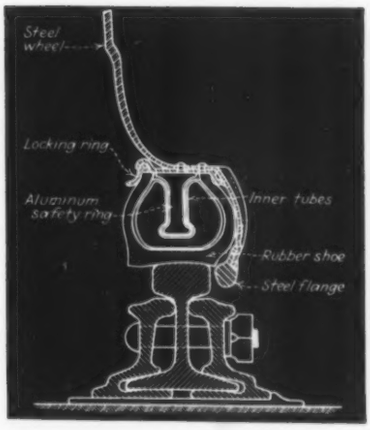
▸ Wheels and Trucks for Rail Cars

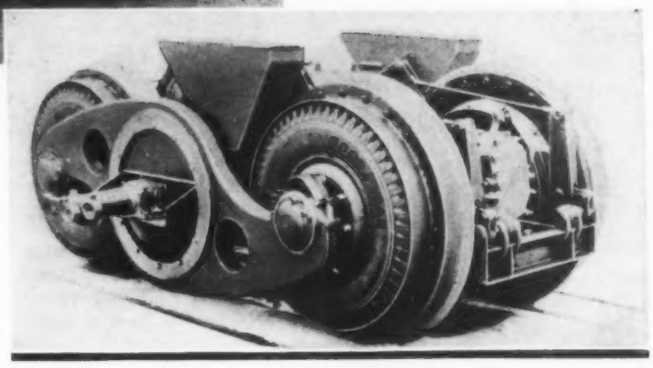
One feature common to all recent developments in lightweight rail cars is increased passenger comfort obtained through elimination of noise and vibration. Although this has been a common aim, details are different in each design. For example, in the construction of the trucks for the Clark Autotram solid steel wheels were replaced with composite wheels having rubber sections, as described in detail in October *P. E.* A similar composite construction is also used in the Stout Railplane, a high-speed light-weight rail car described in November *P. E.* The Railplane uses rubber at every point of contact between the car body and



Built for the Texas and Pacific Railroad, the Budd rail-car and trailer unit is powered by two American LaFrance 240-hyp., 12-cylinder engines driving Westinghouse generators that furnish the power to the traction motors. To the right is shown the shot-welded "stainless" steel frame of the car body







Above—The Budd trailer unit has eight-wheel trucks with wheels, designed as shown in the line drawing. Right—The Howeson four-wheel truck uses a combination of pneumatic tire and steel wheel

truck. The two gasoline engines driving the car are mounted on the truck, rather than the body. In the 4-wheel Howeson truck shown in the illustration, a flexible running gear is combined with pneumatic tires to absorb lateral as well as vertical shocks. The weight of the car is carried on two equalizers, one on each side of the truck, transmitting the load to the two center or driving axles supported by the pneumatic tires. The steel guiding wheels in which the tires run are kept upright and at the proper gage by means of a guiding axle and spherical roller bearings. In case of a flat tire, the driving or pneumatic tired axle drops about $\frac{3}{4}$-in. until the truck frame rests upon the guiding axle, taking the load off the pneumatic tires. Thus, the car can continue in operation and the tire be changed at a terminal point. To remove a tire both pedestals of the equalizer are disconnected and the equalizer rotated until it clears the tires, ordinarily taking about 15 minutes to complete the tire change. Special tires designed for this service have carrying capacities of over 11,000 lb. per tire with mileage in excess of 50,000 miles.

Another method of increasing passenger comfort is exemplified in the new two-unit stainless steel train, shown in the accompanying illustration, built by the Edward G. Budd Manufacturing Company for the Texas and Pacific Railroad. In this train all the power, heating and air-conditioning equipment is built into the forward car which is equipped with two 4-wheel steel tired power trucks. All the passenger accommodations are in the trailer car, supported on two 8-wheel pneumatic tired trucks with the tire tread in direct contact with the rail as shown in the diagram. In the event of a tire failure the wheel drops about $\frac{3}{4}$-in., allowing the load to be carried by the aluminum deflection rings. Flanges attached to the steel wheels keep the tires on the rail.

In addition to the improvements incorporated for increased passenger comfort, many of the construction features built into this two-car unit are being incorporated in the three-unit streamlined Burlington train. Both units of the two-car train are constructed entirely of welded stainless steel. As shown in the accompanying illustration, the frame is welded from built-up sections, and forms a single unit. The complete passenger car weighs only 24,000 lb., or 310 lb. per passenger.

Power for the two-car train is supplied by two 240-hp. 12 cylinder American LaFrance gasoline engines, each driving a 125-kw. generator. Each of the four axles under the power car is driven by a Westinghouse 85-hp. high-speed electric motor through a 5.5 to 1 reduction unit. By the use of aluminum and a self-ventilated design, the weight of these motors is reduced to only 11 lb. per hp. The top speed of the train is 75 m.p.h. with an initial acceleration of $2\frac{1}{2}$ m.p.h. per sec., comparing favorably with the automobile in performance as well as in riding comfort.

▸ Recent Developments in Aircraft Design

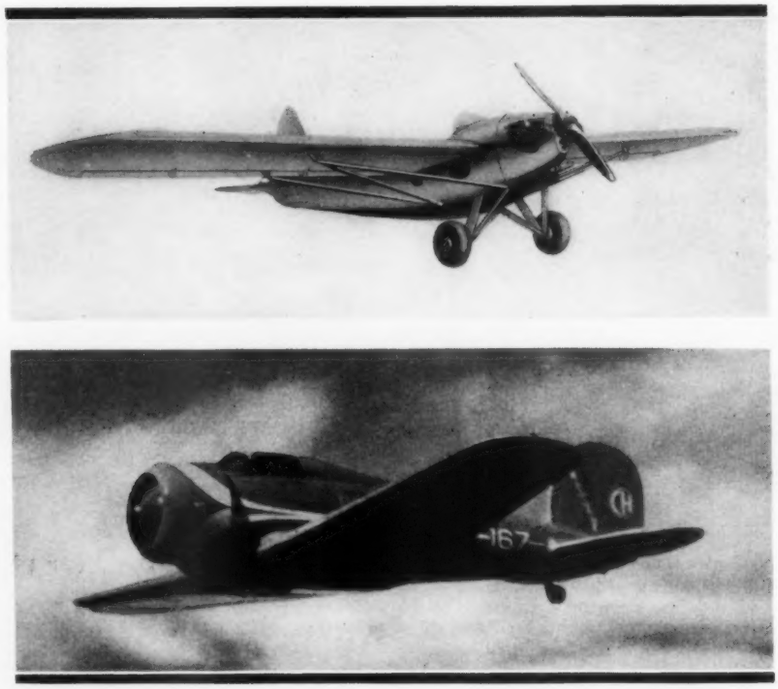
There is a definite trend toward the use of all-metal construction in planes. This is particularly noticeable in the large transports for which the operating companies can afford to pay the price of this construction. This all-metal structure is built up in two forms. In one type, the internal framework carries all of the external loads, and the metal covering is not considered as being a part of the main structure. The Boeing low-wing air trans-

ports and the Douglas Air Liners are of this type. The second type of construction is the monocoque design in which the covering and structure are combined in one unit to carry the external loads. The Lockheed and Martin planes are examples of this type of construction.

With the recent increases in cruising speed, devices for reducing the landing speed are coming into general use. Of these devices, slots and flaps are now being installed on some of the transports including the new Douglas Air Liners. A similar device, the Zap-flap is used on some of the new Northrop monoplanes. Also, controllable pitch propellers are being adopted to allow the engine to operate at a lower r.p.m. while the airplane is cruising at a high speed. In connection with retracting gears now being extensively used, it has become necessary to install warning devices to call the pilot's attention if a landing is approached with the wheels retracted.

With the probable greater use of airplanes by private owners, all these trends are under consideration in new designs for the low-priced market. Quite obviously, the sales of private planes are not yet great enough in number to warrant the expenditure for dies, tools and machinery to turn out such planes in large quantities and at lower prices than at present.

As one attempt at a low-priced plane, the Heath Center Wing plane is designed to carry one passenger at a speed of 85 m.p.h. and can travel 25 to 30 miles on a gallon of gasoline. This plane, shown in the accompanying illustration, is designed around a 40-hp. 2-cylinder air-cooled Continental engine, and is priced at less than $1,200, making it the lowest-priced commercial plane in the world.



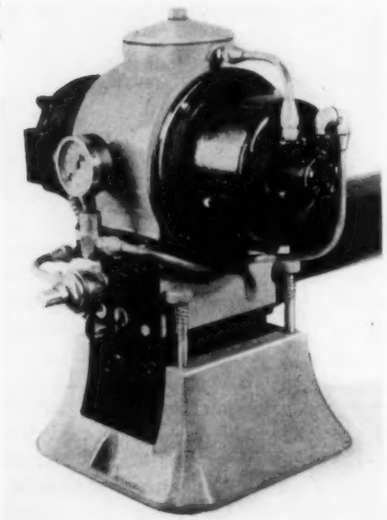
(Above)—The Heath Center Wing plane for private owners is both economical to operate and low in first cost. (Below)—The Orion transport plane embodies recent trends toward low-wing monocoque design with retracted landing gear. This plane carries six passengers and a pilot—top speed is 230 m.p.h.

The Lockheed Orion plane illustrates a significant trend in the design of high-speed transport planes. The monocoque fuselage and low-wing construction makes possible the complete retraction of the landing gear into the wing, as shown in the accompanying illustration of this plane in flight. This design also eliminates all external wing bracing. An increase in the cruising speed to 206 m.p.h. from a former speed of 185 m.p.h. is made possible by a retractable landing gear in combination with a supercharged engine and a controllable pitch propeller.

▸ Smaller Radio Tubes

Driven by the demands of automobile radio set builders, the tube designers have developed laboratory tubes only a tenth the size of the conventional commercial article, and with equally good characteristics. The effect on the size of radio sets of the future is not hard to imagine, particularly when it is known that new core materials for interstage transformers will accomplish corresponding reductions in these units.

Symmetrical design is obtained in this oil burner by making the pump bracket the same size as the motor



▸ An Oil Burner With Eye Appeal

In the design of the Superheet oil burner credit must be given for an appearance comparing favorably with the best designs in other household equipment. A cast-iron base replaces the conventional pipe legs. Mounted on this base by means of a floating suspension, the mechanical unit has a symmetrical shape obtained by making the pump bracket the same size as the motor.

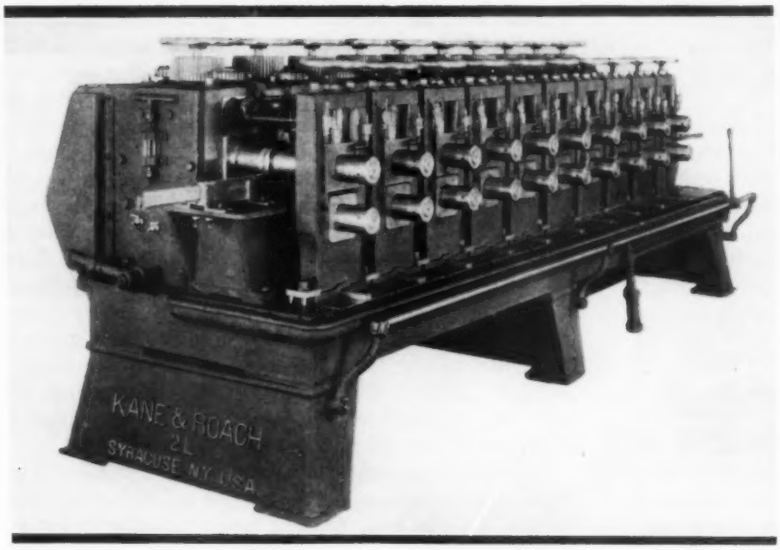
To facilitate servicing, the Monel metal strainer is built-in at the top of the blower housing, where its convenient position encourages cleaning. In the breech unit, removable in one piece from the front, is incorporated the pressure regulating valve in a straight line with the atomizing nozzle, rotor and

electrode rods. Thus individual parts can be serviced without removing other parts.

Eye-appeal is combined with utility in the vitreous enamel finish in two colors, light green for the base and main casting, and black for the breech, motor and pump. All pipes and fittings are cadmium plated.

▸ Cold-Roll Forming Machine

Driven by a 20-hp., 870-r.p.m. motor mounted on the main frame, the Kane & Roach cold-roll forming machine is a completely self-contained unit. For the convenience of the operator, the friction clutch is operated from the shifter rod, accessible the whole length of the front face of the machine. This machine, equipped with anti-friction bearings and oil-tight gear boxes with force feed lubrication, is furnished with ten sets of rolls for forming casement window sash sections at the rate of 120 ft. per min. As exemplified by this and other machines made by this concern, design tendencies are toward the inclosed type cabinet base and general improvement in appearance.



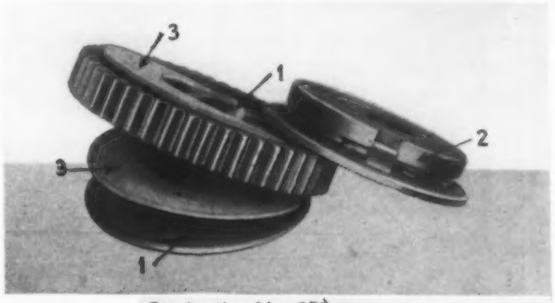
Cold-roll forming machines built by Kane & Roach are capable of forming a number of sections

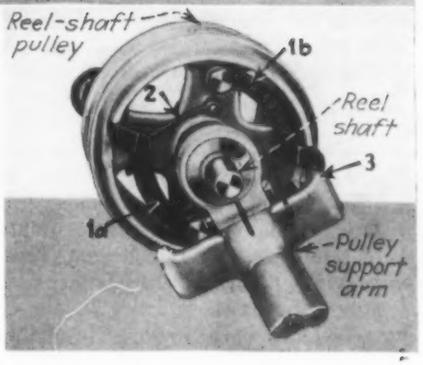
▸ Detail Improvements in Textile Machines

Modernization in knitting machines for the textile industry has brought about several refinements. The Textile Machine Works, for example, has developed special cams, thereby reducing the dynamic unbalance of the camshaft by as much as 90 per cent, increasing the life of the machines and producing more uniform fabric. Also, when the camshaft is shifted for the narrowing operation in full-fashioned hosiery knitting machines, shocks introduced by this operation are eliminated by an air controlled shock absorber on the end of the camshaft.

In full-fashioned knitting machines a weight suspended from a cable wound around the take-up reel rotates the reel around which the knitted fabric is wound as the knitting progresses. This provides the proper tension in the fabric independently of the rate at which the knitting progresses.. However, when the fabric is released from the knitting needles the pull of the weight causes a sudden and rapid rotation of the take-up reel. This may cause the fabric to be caught, resulting in costly damage. To prevent free rotation of the reel when the fabric is released, the safety-stop shown in Fig. 1 was developed. The safety-stop is designed with levers *1*, held in the disengaged position by light tension springs *2*, as shown at the left in the illustration. However, at the slightest increase in pulley speed, occurring when the fabric is released from the knitting needles, centrifugal force overcomes the resistance of the small springs and the levers move outward to the locking position shown at the right in the illustration, catching on projection *3* of the pulley support arm. The maximum distance that the draw-off reel can move after the fabric is released is ½-revolution, a distance not sufficient to cause damage.

Fig. 1 (Below)—Centrifugal force activates the stops when the fabric is released from the needles. Fig. 2 (Right) — Small overload coupling for knitting machines





Another development of this company is a specially designed slip coupling which acts as a release in case of excessive overload. The flanged hub *1*, shown in Fig. *2*, is keyed to the handwheel shaft and on the threaded hub extension carries the pressure plate assembly *2*. Between the pressure plate and flanged hub, and separated from them by leather disks *3*, is the driving gear. The friction between the parts of this coupling depends directly on the spring pressure, which may be varied by screwing the pressure plate in or out on the hub.

The Scope of Photo-Elastic Analysis

A. G. SOLAKIAN
Lecturer in Civil Engineering, Columbia University

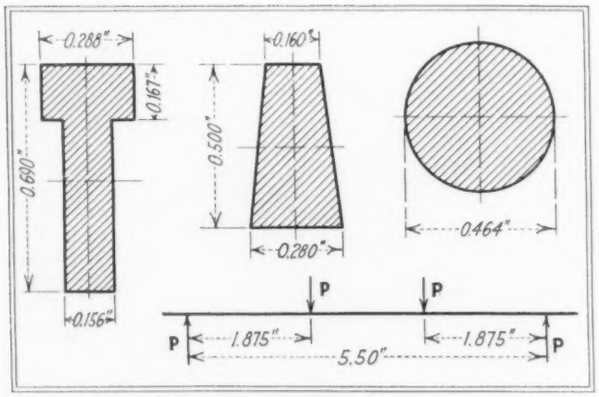


Fig. 1—Photo-elastic stress analysis of these three beams of variable cross-section gave results in close agreement with calculated stresses

ALTHOUGH previous articles in this series have been confined to photo-elastic models of uniform thickness, photo-elastic stress analysis can also be applied to some machine elements represented by models of varying thickness. In using models of non-uniform thickness the chief difficulty encountered is the scattering effect of planes inclined to the polarized light. In addition, models of varying thickness are also difficult to polish, but when Bakelite specimens are immersed in a cell of carbon bisulphide with two parallel glass walls, a high polish is not required.

Since the interference fringes are influenced by the thickness of the plate as well as the intensity of the stresses, when models of variable thickness are used allowance for thickness variation must be made in calculating the stress equivalents of the fringes. Thickness correction is made by multiplying the stress equivalents by the factor t/T, where t is the thickness of the calibrating beam from which the stress equivalent was determined, and T is the thickness of the model at the point considered.

Illustrating the application of photo-elasticity to models of varying thickness, three specimens in the form of bars as shown in Fig. 1 were loaded in bending while immersed in a carbon bisulphide cell. As illustrated in a previous article (April 1933, p. 146), a straight bar of uniform thickness produces symmetrical photo-elastic fringes equidistant from the neutral axis. With specimens of varying thickness the symmetrical arrangement is altered so that the fringes appear as shown in Fig. 2.

Since theoretical stresses in these photo-elastic models can be readily calculated, the reliability of the photo-elastic method can be determined by comparing the theoretical stress distribution with the photo-elastic test results. As shown in Fig. 3, the two methods are in close agreement on the position of the neutral axis, and the extreme stresses, as determined by the two methods, vary less than 4 per cent except in the model of the beam with circular section. The small angle of inclination at the edge of the round specimen accounts for the partial scattering of the light rays close to these extreme fibers. Also, in the round model the three-dimensional stresses undoubtedly differ from the theoretical conception of the stress distribution since the thickness of the beam is about equal to its depth. In sections influenced by three-dimensional stresses, the photo-elastic method applies only when the stresses are constant in one of the dimensions.

As a check on static equilibrium conditions, the principal stresses across the section of a T-beam are shown in Fig. 4. The total tension and compression forces on either side of the photo-elastic neutral axis, as represented by the areas under the curves, agree within 0.8

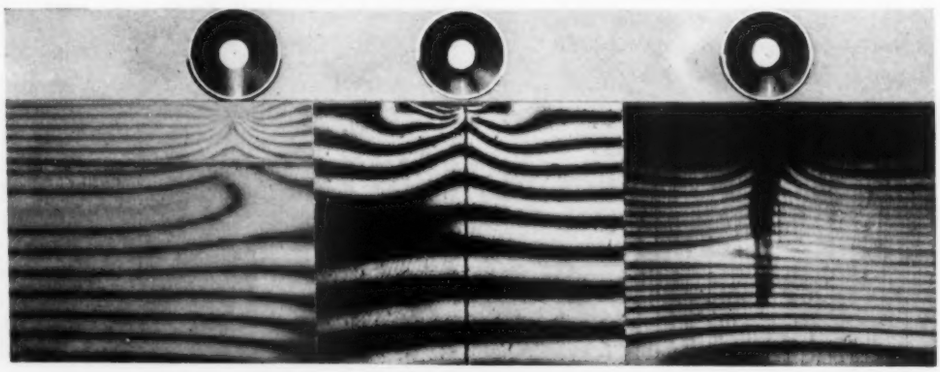


Fig. 2—Fringe photographs of the three beams under load bring out the stress concentration at the point of load application where theoretical analysis is of little value

per cent. Similarly, the bending moment stresses integrated across the section show a difference of only 4.2 per cent between the two sides of the neutral axis. In addition, the total bending moment is within 1.8 per cent of the bending load applied to the beam. This indicates the accuracy of the quantitative results given by photo-elastic methods even when the structural members of machine elements must be represented by models of varying thickness.

For such simple conditions as stresses in beams under uniform loading, stresses in thin rings under uniform circumferential pressure, or stresses in large thin plates under a concentrated load, exact solutions are available, but such simple stress conditions do not often exist in machine elements. When the beam carries an additional concentrated load, or the ring is acted upon by forces which are not uniform, or the plate under a concentrated load is of limited size, the theoretical stress distribution is entirely altered. These additional stresses cannot be determined by theoretical analysis, and a complete solution, in addition to determining the theoretical stresses must account for the modifications. The effect of these modifications can be easily determined by photo-elastic methods

The largest proportion of engineering stress problems still lack an analytical solution, and it is in this field that photo-elastic methods offer the widest application. For example, the stresses in bolt threads cannot be accurately determined by any theoretical means, but as shown in the July, 1933 number, a photo-elastic stress analysis readily indicates the cause of fatigue failures in threaded connections. Likewise, in welded connections, in structures with built-up members, in machine parts with sharp edges and changes in contour or boundary lines, in shafts with keys and in many other structures of very common occurrence the stress distribution can be determined by photo-elasticity.

Data obtained by photo-elastic studies can also be used in formulating empirical laws governing the stress distribution in some types of machine parts. As an illustration, suppose that photo-elastic tests on a set of plates of uniform width having a hole of varying diameter, are compared with the tests on plates with the hole diameter constant and the width varying. The results of these tests, when assembled graphically, will indicate intensity of stresses along any section in a plate with a hole, with both the width of the plate and the diameter of the hole varying. This new relation will be of a general nature and of wider importance. From a curve showing the law of variation of this function, a formula can then be deduced to fit the curve as an empirical solution of the problem.

Photo-elastic stress analysis is not restricted to the use of models cut from a single plate subjected to steady load. In a study of stresses in models under impact or in specimens revolving at high speeds stroboscopic effects have recently been obtained by interrupting the light source in synchronism with the load application or the rotation of the body. Either a stationary or a slow-motion image of the fringe pattern has been produced, and slow-motion pictures have been taken clearly showing changes in stress distributions even when this change takes place with high speed.

Physical Properties of Bakelite

Ultimate tensile strength	14,000 lb. per sq.in.
Ultimate compressive strength	25,000 lb. per sq.in.
Elongation in tension	3 per cent
Deformation in compression	5.5 per cent
Elastic modulus in tension	675,000 lb. per sq.in.
Elastic modulus in shear	264,000 lb. per sq.in.
Poisson's ratio	3.6
Index of refraction	1.577

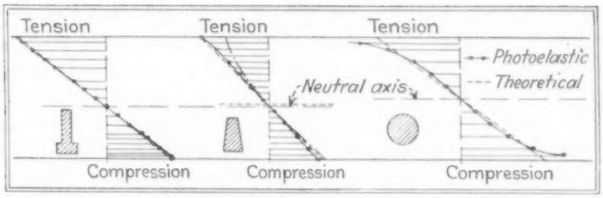


Fig. 3—Comparison of photo-elastic and calculated stresses in the three beams shows good agreement both as to stress distribution and location of neutral axis

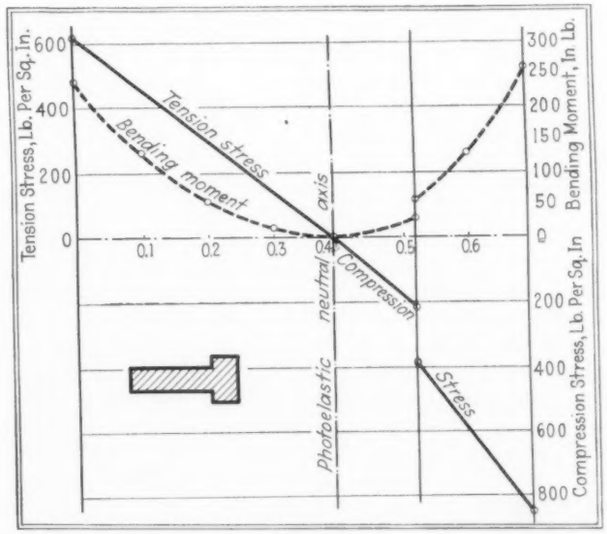


Fig. 4—Static equilibrium and bending moment conditions are also satisfied by the results of the photo-elastic analysis

In the manufacture of specimens for photo-elastic analysis models can now be made of several pieces or of composite materials. In analyzing stresses in welded connections, specimens are assembled from several pieces cemented together directly on their surfaces in contact or through fillets as in welding. To represent elements of reinforced concrete structures, models are prepared from Bakelite castings with embedded metal rods.

As stated in previous articles, clear Bakelite is in general use for photo-elastic models, and some of the limitations of this material influence the quality and cost of photo-elastic tests. Material for models is available only in plates about 7 × 12 in., from ¼-in. to 1⅛-in. thick, so that one-piece photo-elastic models are limited in size by these dimensions. As indicated from the physical properties shown in the accompanying

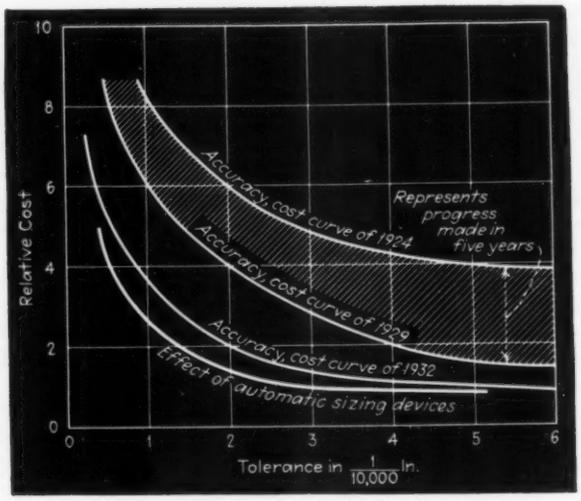
table, the elastic strength of Bakelite is comparatively low. For this reason, Bakelite models should not be loaded to a greater stress than required to produce about twelve fringes. The use of stresses producing a greater number of fringes introduces creep action which alters the true stress distribution condition in the model. Even with comparatively low maximum stress conditions, some creep is noticeable in the first few minutes after applying the load, and for this reason fringe photographs are usually taken after 20 to 30 minutes under load.

To the designing engineer it will be apparent from this series of articles that there are three practical applications of photo-elastic stress analysis: (1) To verify calculations and check assumptions made in designs for which theoretical solutions are available. (2) To supplement calculations in designs to which special solutions may not completely apply. (3) To solve engineering problems where no analytical methods are available. Stress problems in engineering design rarely have an exact mathematical solution, and those conditions that do submit to exact analysis do not often exist in machine elements. When assumptions are made to fit the theoretical solution to the stress conditions as closely as possible, photo-elasticity verifies the result of the assumptions.

▼ ▼ ▼

Initial Wear

R. E. W. HARRISON
Cincinnati, Ohio



Recent improvements in machine tool performance provide closer control over accuracy at little increase in cost, especially in the finer tolerances

TOTAL permissible wear between rubbing surfaces, usually the controlling factor in the useful life of machines, is influenced by three conditions: initial clearance, initial wear occurring during running-in, and natural wear which is to a large extent controlled by the efficiency of the lubricating system. Particularly in mechanisms having a relatively short useful life because of narrow limits of permissible wear, the return on the investment in the entire machine depends on the performance of a thin skin of material at the bearing surfaces. Because of this fact, proper control and distribution of initial wear is an important factor in determining the serviceable life of all machines.

The amount of initial wear which occurs during running-in depends on the surface condition or finish. Two new surfaces in contact, when magnified, appear as two sets of saw teeth with only the points of the teeth in contact. At these points of contact between the surfaces, unit pressures are extremely high and metal particles in contact are torn out of place or worn down. As the high spots on both the journal and shaft are worn off during the running-in period, a relatively smooth bearing surface develops. Lubricants during this period act largely as cooling and flushing agents. It is the character of the new surfaces rather than lubrication or the physical properties of the metals themselves that determines the amount of initial wear.

In automobile, motor bus, and airplane engines and other fine mechanisms, noise introduced by wear at the bearing surfaces usually limits the life of the parts. Even though the parts may continue to function properly, noise is objectionable. Reduction in the amount of initial wear with a resulting prolonged quiet operating life is obtained through the use of a higher grade finish for bearing surfaces.

In the design of railroad axles the dimensions of the journal bearings are selected to carry the load with a specified safety factor taking into account the minimum safe diameters to which these axles may be re-machined or worn down. Since the permissible range of wear plus the metal taken off in re-machining is seldom allowed to exceed a skin 3/16-in. thick, the useful life of the complete axle is dependent entirely upon the life of this thin skin. With the use of precision grinding equipment in axle maintenance, a number of railroads, including one Canadian railroad, have found it possible to lengthen the life of this surface. The combination of high initial accuracy and finish and the relatively small depth of material removed by precision grinding, decreases the amount that the diameter is reduced in each resurfacing operation. In addition, wear is more uniform in precision ground axles. It is often found that the wear is so well distributed that journal bearing surfaces are still within the required limits for

roundness, parallelism and finish after as much as 12 to 16 months of service.

As another example of useful life depending on the performance of a thin bearing surface, the life of inspection gages is governed by the initial wear. Higher quality finishes produced by precision grinding and lapping are used to increase useful life by cutting down the range of initial wear, not only in gages, but also in optical instruments, engraving dies, chilled iron rolls, machine tools, large telescopes and big rifles, and in many other machines in which a high initial investment depends for its return upon the service obtained from the bearing.

In addition to specifying the finish, the engineer must also specify the sequence of finishing operations, the tooling or the grades of grinding wheels, and the hones or laps used. Only by specifying the finishing operations can the designer establish finish costs, and evaluate finish costs in terms of initial bearing wear. In machinery permitting a large amount of total wear, such as, for example, agricultural equipment, the maximum amount of wear is of relatively little importance. Going to the other extreme, total allowable wear in crankshaft bearings in automobile engines is so small that initial wear is the important factor.

Accessibility or ease of replacement also enters into the selection of the bearing finish. A 50 per cent increase in the finishing cost of a bearing in a printing press would certainly be justified by even only a slight increase in the expected service life. On the other hand, in a $50 washing machine having ten or fifteen bearings, high cost finishes would not be justified for easily replaceable bearings. Selection of the type of finish must, therefore, take into account not only the cost of the finish in relation to the cost of the part itself, but also the relation between initial wear and total wear as well as the relation between the finishing cost and the cost of the complete machine.

In determining the manufacturing tolerances, the first factor to consider is the maximum allowable clearance between the two mating parts. From this must be subtracted the initial wear and the minimum running clearance. What remains represents the maximum permissible initial clearance. The manufacturing tolerances for the bearing and journal must then be selected so that the initial clearance will fall between the two limits as determined above. If the surface finish is made

Anticipated Initial Wear for Various Finishes on a 1-in. Diameter Shaft

Finish	Decrease in Diam. Through Anticipated Initial Wear	Grinding Operations	Grit of Wheel	Relative Cost in Units
Rough	0.0006 in.	Single	30 to 60	1.0
Commercial	0.0004 in.	Rough Finish	40 to 80 same wheel	1.6
Tool Room	0.0002 in.	Rough Semi-Finish Finish	40 to 80 same wheel 120	2.4
Fine	0.0001 in.	Rough Semi-Finish Semi-Finish Finish	40 to 80 same wheel 120 to 320 500-900	3.2

In response to numerous requests from readers and because of the great interest aroused in the 1933 series of Case Histories, we have induced Mr. Maloney to prepare for our readers a similar series for 1934. The first installment will appear in the January number

▼

smoother and the initial wear is thereby decreased, greater manufacturing tolerances can be used. Closer tolerances do not necessarily indicate a finer surface finish. On the other hand, a finer surface finish almost invariably carries with it closer tolerances. Hence the net result of a better surface finish is usually a machine that runs smoother because of improved bearings and also one that has a longer useful life.

When specifying the finish and the sequence of operation, the work required must be within the limitation of the manufacturing personnel and the machine tool equipment. Recent developments in machine tools and especially in grinding, lapping and honing equipment have reduced the cost of small tolerances so that as in the curve shown here, a tolerance of plus or minus 0.0001 in. can be obtained today at approximately the same cost as a tolerance of twice that amount with the best equipment that was available only three years ago.

To emphasize the controlling effect of the finish specifications on initial wear, the accompanying table gives the anticipated initial wear in the diameter under each of four grades of finish. The same finish, of course, must be applied to both surfaces in contact, as the dimensions given for anticipated wear represent, roughly, twice the height of the imperfection at the mating surfaces. The finer finishing operations using successively finer grades of grinding wheels, result in a finish having relatively smaller imperfections and consequently lower initial and lower total wear. Consideration of the accuracy-cost curves in conjunction with the table of anticipated wear and relative finishing cost emphasizes the futility of making a heavy investment in accuracy without a corresponding investment in quality of finish. The high initial accuracy is soon lost if the quality of finish is not correspondngly fine.

Although chromium plating adds materially to the life of many bearing surfaces by reducing the wear, chromium plating itself is no substitute for quality in the finish before plating. When a coarsely ground surface is chromium plated the plating builds up the ridges and enlarges the defects. Unless the finish on the bearing surface is as good as that desired after plating, but little advantage can be gained by chromium plating in reducing initial and total wear.

It is in the selection of the finish for the bearing surfaces that the designer exerts his control over the initial wear and the useful life of the bearing. The use of modern machine tools makes it possible to obtain higher quality finishes and consequently increased bearing life at lower cost.

Wire Locks and Snap

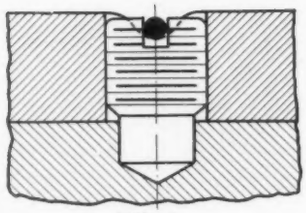


FIG. 1

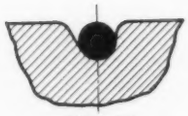


FIG. 3

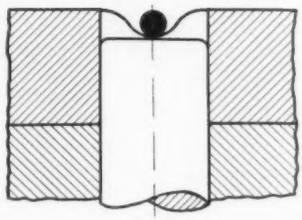


FIG. 2

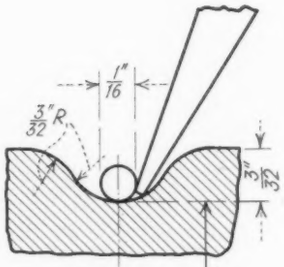


FIG. 4

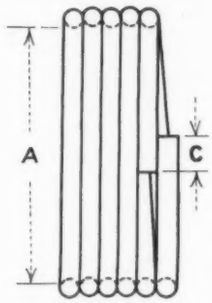


FIG. 5

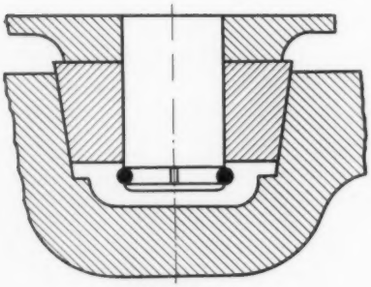


FIG. 6

ADAM FREDERICKS

Frequently considerable savings can be made by the substitution of wire locks or snap rings in place of expensive tapping operations, or to eliminate the necessity of boring holes to two different diameters and grinding shafts to shoulders. Often, screws and lock nuts can also be eliminated.

Wire locks and snap rings can be used only where the loads are radial and thrust loads are light. Spring steel or music wire is usually used for the material. Usually, $\frac{1}{16}$-in. diameter wire is sufficiently large. In nearly all of the accompanying illustrations the wire size is shown exaggerated.

Figs. 1 and 2—Two common applications for wire locks to a screw or a pin.

Fig. 3—The two forms of grooves shown here should be avoided, as each offers too much difficulty in snapping off the ring, particularly when the outside or outermost diameter of the wire ring is below the surface of the work.

Fig. 4—Enlarged view of a successful type of groove, the rounded edges permitting the wire to be snapped out with greater facility.

Fig. 5—Wire locks may be made in the form of a close wound spring and successive coils cut off to suit. Diameter *A* should be $\frac{1}{16}$-in. smaller than the diameter *B* indicated in Fig. 4. Lap *C* should be $\frac{3}{16}$ in. for each $\frac{1}{16}$-in. difference between diameters *A* and *B*.

Figs. 6 to 8—Three typical applications of snap rings.

Fig. 9—Spring lock of $\frac{3}{64}$-in. wire on a $\frac{1}{4}$-in. diameter pin, as used in a well-known universal joint. Once assembled, the spring lock cannot snap out.

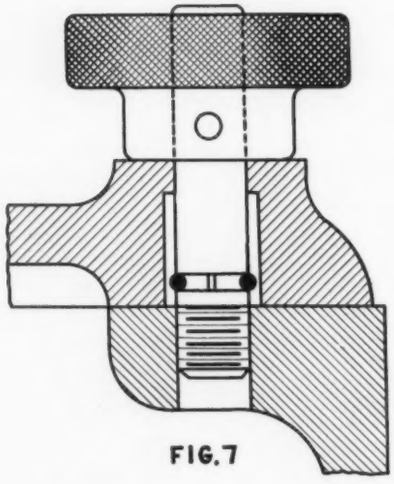


FIG. 7

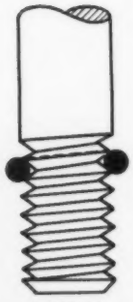


FIG. 8

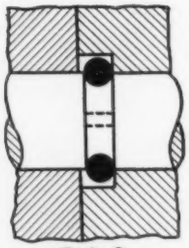


FIG. 9

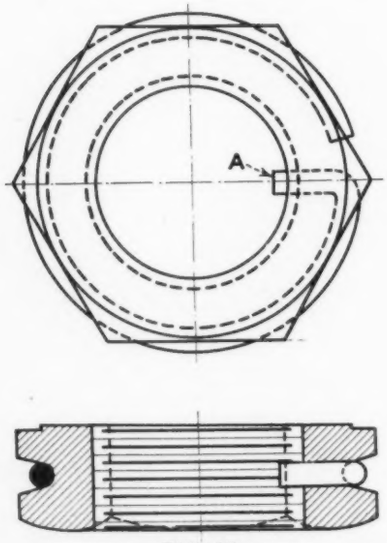


FIG. 10

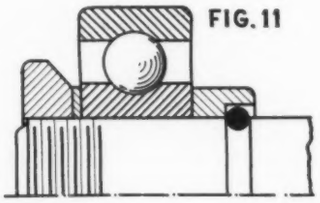


FIG. 11

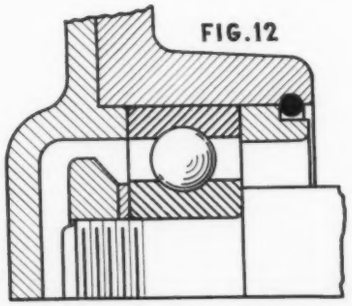


FIG. 12

Rings for Fastenings

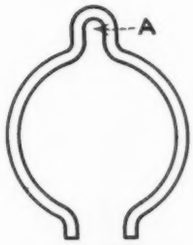


FIG. 13

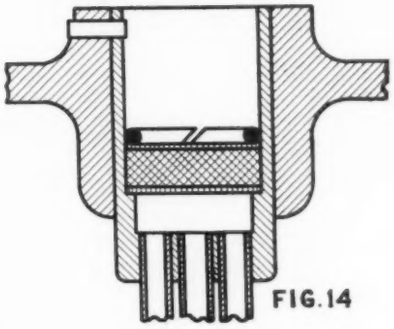


FIG. 14

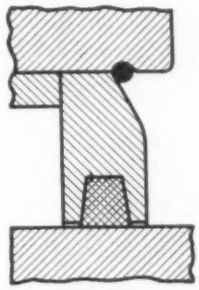


FIG. 15

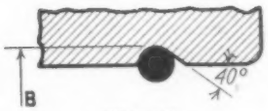


FIG. 16

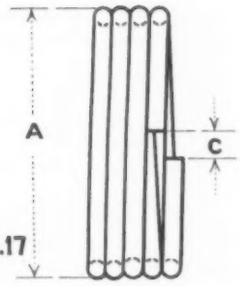


FIG. 17

Fig. 10—A hole in the shaft receives the end *A* of the spring lock. When the position of the nut is changed a new hole must be drilled in the shaft.

Figs. 11 and 12—Typical applications of wire locks.

Fig. 13—Press-formed external wire lock. Loop *A* allows insertion of a wire puller when disassembling.

Fig. 14—Application of a wire lock in a lubricating device to hold the wire mesh screen and felt in place.

Fig. 15 and 16—Felt seal housing held in place by a wire lock, and enlarged view of groove.

Fig. 17—Method of cutting internal lock rings from a close wound spring. Diameter *A* should be $\frac{1}{16}$-in. larger than diameter *B* and gap *C* is $\frac{1}{2}$ in. for each $\frac{1}{16}$-in. difference between diameters *A* and *B*.

Figs. 18 and 19—Wire locks for the felt seal housing of a tapered roller bearing. In Fig. 19 is shown the enlarged view showing the different positions taken by the wire lock for a various of plus or minus $\frac{1}{32}$ in. axially.

Fig. 20—Wire lock, internal, applied to a sheet metal stamping.

Fig. 21—Wire lock in the outer race of an open-end bearing to make it integral.

Fig. 22 to 26—Typical snap ring made of rectangular spring and various applications of snap rings made of rectangular stock, as applied to roller bearings and ball bearings.

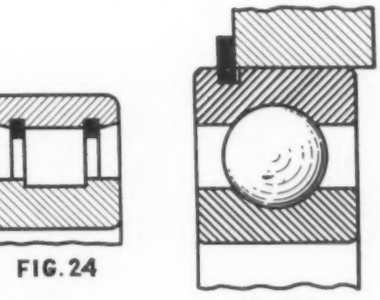
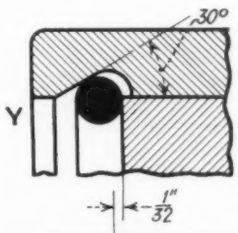


FIG. 18



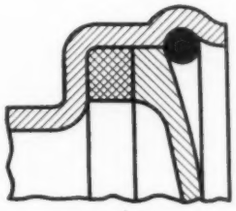


FIG. 20

FIG. 22

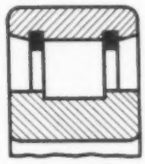


FIG. 24

FIG. 25

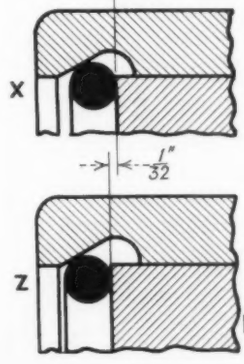


FIG. 19

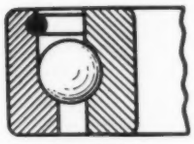


FIG. 21

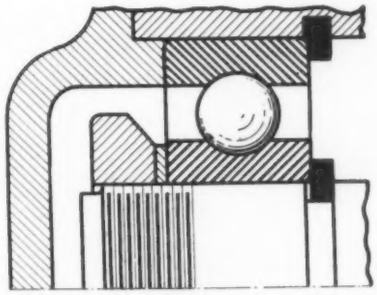


FIG. 23

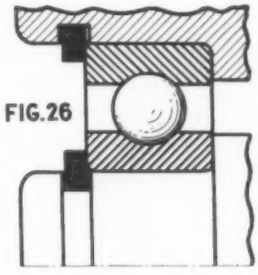


FIG. 26

Types of Plastics and Their Properties

H. M. RICHARDSON
Application Engineer, Plastics Department
General Electric Company

The various types of hot and cold molded plastics, the fillers and binders used, and a comparison of physical and chemical properties of plastics, rubber and fiber. In a second article the author will show the design calculations for several typical machine elements made of phenolic laminated plastics

SINCE the advent of synthetic resin into the commercial field in 1909, plastics have become so widely applied that they now rank with metal, wood and stone as one of the principal materials of construction. They possess such a remarkable assortment of properties, both mechanical and electrical, that they cannot be considered as a substitute for the older and more commonly known materials but must be considered as a distinct group, replacing and supplementing the older materials. Plastics products constitute one of the major groups of materials suitable for electrical insulation or mechanical applications. They are compositions formed under high pressure in steel molds. By chilling or as a result of chemical reaction under heat, either accompanying or subsequent to the molding, the products become rigid.

Predominant among the characteristics which give plastics their broad applications are:

1. Simplification and improvement of apparatus design by using plastics products as both structural and insulating material.
2. Availability of colors and variety of designs permitting distinctive and decorative effects not readily obtainable with metal.
3. Elimination of the necessity for surface treatment such as plating, polishing, painting, varnishing, enameling or similar operations.
4. Freedom from rusting or tarnishing.
5. Resistance to weather, water, oils, solvents, salt air, washing soaps, cleaning fluids, and most acids.
6. Low heat conductivity which renders the product comfortable to the touch.
7. High ratio of strength to weight.
8. Resilience to absorb mechanical shock.
9. Low density as compared to other structural materials.
10. Versatility of form.

Because of low dielectric loss and permanence of electrical properties, phenolic laminated materials are used for radio parts

Plastics products usually consist of a binder and a filler. The binder serves to render the mass plastic while it is being formed under pressure and gives it coherent mechanical strength and stability. Different kinds of fillers are used to give a wide variety of physical characteristics to the finished material. A large number of grades and compounds of these plastic materials have been perfected by using different types of fillers and binders to give combinations of the above tabulated characteristics in almost any proportion. Certain grades excel in mechanical strength and resilience; others have outstanding electrical properties. Some remain inert when subjected to high temperatures and electric arc, others are impervious to water absorption, while others resist the action of most chemicals. Some are susceptible to molding into intricate shapes while others are more readily machined to the desired form.

Laminated plastics, for example, can be given any of the usual machining operations. No unusual precautions are required. The tools should be kept well sharpened. Punching and shearing can be done better

when the material is warmed. Light oil or turpentine is used for tapping or threading, these being the only operations on which it is desirable to use lubricant.

The plastics are usually classified as follows:

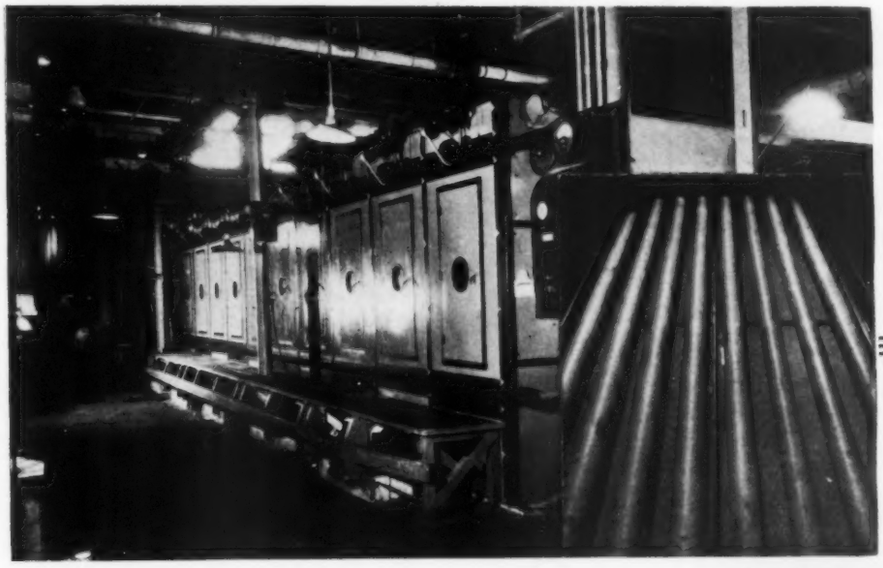
1. Laminated using a synthetic resin binder
   (a) Cotton cloth filler
   (b) Asbestos cloth filler
   (c) Rag paper filler
   (d) Kraft paper filler
   (e) Asbestos paper filler
2. Hot molded, using synthetic resin binder.
   (a) Wood flour filler
   (b) Cotton fiber or fabric filler
   (c) Asbestos filler
3. Cold molded with organic binder
   (a) Asbestos filler
4. Cold molded with inorganic binder
   (a) Asbestos filler

Laminated grades are made primarily for mechanical and electrical uses and are produced in the form of sheets, tubes and rods which may be fabricated into desired shapes. The laminated grades can also be molded into simple shapes of relatively uniform cross-section or may be combined with some of the hot molded compounds to form more intricate shapes.

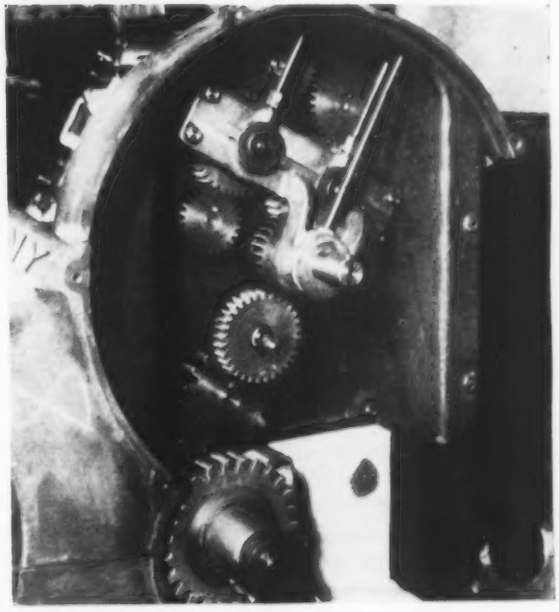
As may be gathered from their names, the laminated products are built up of laminations or plies of paper or fabric which has been impregnated with the synthetic resin varnish. Sheets or laminations to the proper weight to give the final thickness desired are stacked and pressed between the heated plates of a large hydraulic press. The heat renders the synthetic resin plastic and the pressure compacts the stack of laminations into a uniformly dense homogeneous sheet. Continued application of heat causes chemical reactions in the synthetic resin binder, changing it into a hard substance. Heat and pressure are maintained on the material until the desired degree of chemical change in the binder has taken place. As the hardness is the result of a chemical reaction, the resin binder cannot be rendered plastic by subsequent heating.

Laminated tubes are made by either one or two methods designated as "molded" or "wrapped" tubing. Molded tubing is made on a mandrel the size of the desired inside diameter of the tube and rolling or wrapping enough of the impregnated laminated material around the mandrel to give the desired wall thickness. This assembly is then placed in a mold and subjected to the desired curing temperature and pressure. The wrapped tubing is made by winding impregnated sheets of the material on a hot mandrel which is rotated under pressure exerted by three heated rolls. In this method the bonding resin is fused and bonded to the adjacent layer by the roll pressure as the material is being wrapped. After the tube is wound, it is subjected to a further heat-treatment which chemically changes the bonding resin into its permanently infusible and insoluble state.

Laminated rods are made in much the same way as molded tubing in that the desired weight of the material is wound on a mandrel of extremely small diam-



Because of its high resistance to heat and corrosion, laminated phenolic molded parts are used extensively in the textile industry. The insert shows laminated rollers used in the carbonizing machine here illustrated



Phenolic laminated gears properly designed and cut from blanks are quiet running and have long life

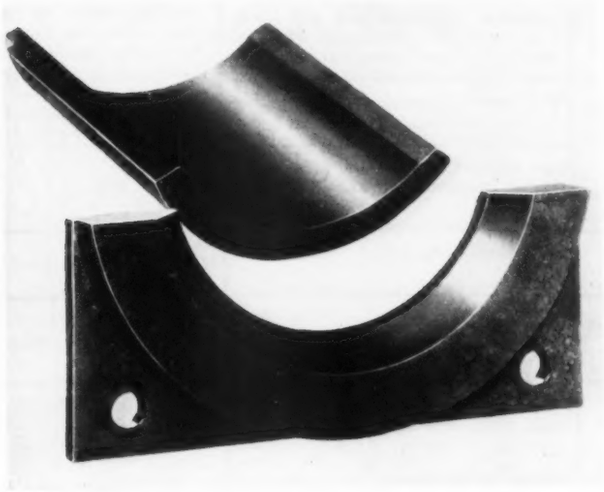
Comparison of Average Properties of Three Common Insulating Materials

PROPERTIES	HARD RUBBER	VULCANIZED FIBER	LAMINATED PHENOLIC
Power Factor (at radio frequencies)	0.01 to 0.03	0.05	0.03 to 0.07
Dielectric Constant (at radio frequencies)	2.7 to 4.0	5	4.5 to 6
Dielectric Strength (Specimen $\frac{1}{8}$-in. thick. Step by step test at 25 deg. C.)	500 to 1,000 volts per mil	25 to 250 volts per mil	150 to 600 volts per mil
Tensile Strength	3,000 to 5,000 lb. per sq.in.	9,000 to 16,000 lb. per sq.in.	6,000 to 20,000 lb. per sq.in.
Water Absorption (per cent in 24 hr.)	0.02	20 to 60	0.3 to 2.5
Specific Gravity	1.2 to 1.5	1.2 to 1.4	1.3 to 1.4
Coefficient of Linear Expansion (per deg. C.)	60 to 80 x 10^{-6}	25 x 10^{-6}	20 to 30 x 10^{-6}
Effect of Aging	Deteriorates slowly unless well vulcanized and protected from light	Improves	Improves
Effect of Heat	Softens at 50 to 65 deg. C. Melts at 200 deg. C.	Will not melt; not readily inflammable, but chars and becomes brittle at high temperature. Burns at about 340 deg. C.	Not readily inflammable. Temperatures from 60 deg. C. to 150 deg. C. tend to renew chemical reactions, resulting in shrinkage and loss in weight
Effect of Sunlight	Discolors and disintegrates after a few months. Sulphate films formed on surface reduce surface resistivity	No effect	No visible effect
Effect of Ultra-violet Light	A few hours exposure is in its effects equivalent to many months exposure to sunlight	No data	Lowers surface resistivity
Effect of Moist Air	No effect	Absorbs water freely but without permanent injury; while saturated it becomes soft and flexible and swells; warps and twists upon drying	Absorbs slight amount of water, reducing dielectric properties
Effect of Steam	The only effect is that resulting from the high temperature	Same as above, except absorption is more rapid	Best grades not affected beyond slight absorption of moisture; after a few days in steam the cheaper grades will swell appreciably and split, superheated steam tends to warp and blister all grades
Solvents	Affected by most organic solvents and mineral oils; unaffected by alkalies, weak acids and certain concentrated acids	Organic solvents have no permanent effect; oils are slightly absorbed; affected by acids and alkalies	Not affected by most organic solvents, oils, or weak acids; attacked by alkalies and strong acids
Metallic Inserts	Hard rubber is rapidly deteriorated by contact with iron or copper, the metals themselves also corroding. Inserts should be coated with tin, paper, unvulcanized rubber or other mutually protecting medium	No effect	No effect
Machining Qualities	Admits of a high polish but machines less accurately than would be supposed, because of its great resiliency. It has tendency to warp; can be molded but not accurately to size	Admits of a fine finish; may be sawed, punched, drilled, stamped, embossed, turned, planed, bent, tapped	Admits of a good polish; can be sawed, punched, drilled, stamped, turned, planed, knurled, embossed, milled, tapped either with or against the grain, though not as easily as hard rubber and vulcanized fiber

eter and after withdrawing the mandrel the material is then molded in a preheated mold.

The nature of this laminated structure must be kept in mind when applying these materials since both the electrical and mechanical properties are directional with respect to the plane of the laminations. For instance, the tensile strength of laminated products is much greater when the load is applied in the plane of the laminations than it is if the load is applied perpendicular to the plane of the laminations. On the other hand, dielectric strength is much higher when the electrical stress is perpendicular to the laminations than when it is parallel to the laminations.

The table on the following pages gives a list of the standard grades of phenolic laminated materials as



Its ability to absorb impact loads and its low coefficient of friction, has resulted in laminated phenolic materials being used for roll-neck and other bearing applications

classified by the National Electrical Manufacturers Association and indicates the physical and electrical properties of each grade. For ease of comparison, the properties of hard rubber and vulcanized fiber are also included in the list since many of their properties are comparable with those of the phenolic laminated products. It should be emphasized that the properties of the various grades as set forth in the table represent average values.

Certain of the above properties and combinations of properties are unique with phenolic laminated materials. For example, it will be noted that the density is just half that of aluminum and that the specific strength or strength for a unit of weight, which is important in the construction of certain devices, is extremely high as compared to other structural materials. It will also be noted that the modulus of elasticity of phenolic laminated materials is much lower than that of any of the metals. It is about one-fortieth that of steel. This combination of strength, with the low modulus of elasticity, gives the material its great importance in the design of machinery with rapidly moving parts that are subjected to impacts.

The properties of vulcanized fiber are comparable to the fabric base phenolic laminated materials with the exception of water absorption. For this reason, phenolic laminated materials have a marked superiority over vulcanized fiber on applications where warpage, changes of dimensions or changes of electrical properties must be avoided and atmospheric humidity or exposure to moisture are encountered.

In many instances the electrical properties of hard rubber are superior to those of phenolic laminated materials but on the other hand, hard rubber is subject to deterioration from aging and exposure to sunlight and will not withstand temperatures as high as those that can be withstood by phenolic laminated. Hard rubber is also more subject to cold flow and often causes deterioration of metallic parts that come in direct contact with it.

In the selection of a structural material for a particular application, the task of the designing engineer is to find a material with the right combination of properties to allow him to improve and simplify his product. Thus, any group of materials which has a unique combination of properties finds a definite and valuable place in apparatus design.

The electrical manufacturing industry is, at the present time, probably the largest user of phenolic laminated materials. The reason for this is that these materials have a good combination of electrical and mechanical properties. As a group, they are good insulators. They have high dielectric strength and low leakage. They will withstand as high operating temperatures as any of the other usual insulating materials. Their high mechanical strength and resilience allows the use of simplified parts which combine both mechanical and electrical strength. Furthermore, a great many such parts can be easily fabricated from sheet, tube, rod or simple molded shapes.

In the manufacture of radio receiving sets, phenolic laminated materials are used extensively. The properties which are responsible for this are low dielectric loss and permanence of electrical properties under changing atmospheric conditions. Added to this is the fact that phenolic laminated materials are easily fabricated into punched parts and coil forms which constitute the principal insulations in a radio set.

One of the earliest applications of fabric base laminated material was in the manufacture of gears and pinions. In this application strength and elasticity are the most valuable properties. In the operation of any gear train, there is bound to be a certain amount of minute discontinuity of gear tooth action owing to the unavoidable variation in gear tooth spacing and profiles. For this reason the transition of contact from one pair of teeth to the next is accompanied by a certain amount of impact and acceleration. This is the condition which sets up the usual noise in a gear train. Where all the gears are metal, the deflection of the teeth under load is small as compared to the minute variations in tooth profiles and spacing while, on the same basis of comparison the deflection of the teeth of phenolic laminated gears is relatively high. By having every other gear in the train made of phenolic laminated material, having high resiliency, the transition from one tooth mesh to the next is much more gradual and is not accompanied by high impact, as in metallic gears. The net result is much quieter operation than with metallic gears cut to the same degree of accuracy.

Properties of Phenolic Lami

Contributed by H. M. Richardson, Application Engineer,

N.E.M.A. CLASSIFICATION	BASE MATERIAL	COLORS	FINISHES	PREDOMINANT CHARACTERISTICS	GENERAL USES	WAT A
						Size of Sample in In.
X	Paper	Natural tan, black; also black surface, natural core	High polish, satin	High mechanical strength — good machining qualities — can be satisfactorily punched while hot	These four grades have been developed primarily for insulation in the radio, electrical, and electronic fields. They offer insulating qualities in different values up to the most exacting requirements. Grade selection depends on the electrical and mechanical strength required by the application	1x3x$\frac{1}{16}$
P	Paper	Natural tan, black; also black surface, natural core	High polish, satin	Excellent cold-punching and shearing qualities, consistent with fair mechanical and electrical properties		1x3x$\frac{1}{16}$
XX	Paper	Natural tan, black	High polish, satin	High insulating value, good machining and mechanical qualities		1x3x$\frac{1}{16}$
XXX	Paper	Natural tan, black	Satin	Low dielectric losses and low power-factor under high-humidity conditions		1x3x$\frac{1}{16}$
XX	Paper	Natural tan	Ground	High insulating value. Tube form only	Any insulating purpose	1x2x$\frac{1}{2}$
A	Paper (Asbestos)	Natural tan, black	Satin	Unusually high heat resistance	General insulation and mechanical uses where heat resistance is of primary importance	1x3x$\frac{1}{16}$
AA	Fabric (Asbestos)	Natural tan, black	Satin	High heat resistance — mechanical strength — low moisture absorption	Similar to Grade A, but offering greater mechanical strength — used for valve disks in contact with steam, etc.	1x3x$\frac{1}{4}$
D	Paper	Red, green, etc.; also marble, mahogany, walnut, and others to order	High polish, satin dull	Decorative	Wall panelings, table tops, desk tops, and general decorative uses	1x3x$\frac{1}{16}$
LE	Fabric (Fine-weave)	Natural tan, black	High polish, satin	Good electrical and machining qualities	Replaces other grades for electrical and radio insulation when greater toughness and resilience are also desired	1x3x$\frac{1}{4}$
LE	Fabric (Fine-weave)	Natural tan	High polish, satin	Good electrical and machining qualities, plus low water absorption	Where exact dimensions must be maintained on machined parts and remain unchanged under temperature variations, and where resistance to water absorption is important, such as sleeve bearings in deep-well pumps and for gasoline-pump vanes, etc.	1x3x$\frac{1}{4}$
CE	Fabric (Medium-weave)	Natural tan, black	High polish, satin	High mechanical strength with good machining and electrical properties	General mechanical uses	1x3x$\frac{1}{4}$
CE	Fabric (Medium-weave)	Natural tan	High polish, satin	High mechanical strength with good machining and electrical properties, plus low water absorption	Similar to Grade CE, particularly where it must remain unaffected by water absorption	1x3x$\frac{1}{4}$
L	Fabric (Fine-weave)	Natural tan	Satin	Tough, resilient, high mechanical strength and good machining qualities	Fine-pitch gears, intricate punchings, and for mechanical uses	1x3x$\frac{1}{4}$
C	Fabric (Heavy-weave)	Natural tan	Satin	Excellent wearing qualities — greatest possible resistance to impact loads	For non-metallic industrial gears and for mechanical uses where unusual toughness and a high ratio of strength to weight are required	1x3x$\frac{1}{4}$
L	Fabric (Fine-weave graphite-impregnated)	Black	Satin	High mechanical strength, low water absorption — low coefficient of friction when lubricated	Water-lubricated bearings	1x3x$\frac{1}{4}$

Laminated Molded Materials

n Engineer, Plastics Department, General Electric Company

	WATER ABSORPTION AT 30 DEG. C.			COMPRESSIVE STRENGTH		FLEXURAL STRENGTH (Modulus of Rupture)	TENSILE STRENGTH (Lb. per Sq. In.)	DIELECTRIC STRENGTH (Short time) $\frac{1}{16}$-in. Thick at 25 deg. C. Volts per Mil	POWER FACTOR At 1,000 KC. and 25 Deg. C.		DIELECTRIC CONSTANT At 1,000 KC. and 21 Deg. C.	
	Size of Sample in In.	After 24 Hr. (Per Cent)	Saturation	Flatwise (Lb. per Sq. In.)	Edgewise (Lb. per Sq. In.)				As Received	After 24 Hr. in Water	As Received	After 24 Hr. in Water
	1x3x$\frac{1}{16}$	2.0	6.5	31,000	——	21,000	12,500	700	0.05	0.075	5.5	6.5
level- n the ields, n dif- cting n de- hani- plica-	1x3x$\frac{1}{16}$	3.0	12.0	23,500	——	15,000	8,000	600	0.06	0.09	5.5	6.5
	1x3x$\frac{1}{16}$	1.3	6.0	35,000	——	16,000	8,000	700	0.045	0.060	5.5	6.0
	1x3x$\frac{1}{16}$	1.0	6.0	35,000	——	15,000	7,000	650	0.035	0.045	5.0	6.0
	1x2x$\frac{1}{2}$	2.0	——	——	——	——	——	250 ($\frac{1}{2}$-in. thick)	0.007 (at 1 kc.	——	——	——
anical prim-	1x3x$\frac{1}{16}$	0.5	——	25,000	——	15,000	8,000	150	——	——	——	——
fering - used team.	1x3x$\frac{1}{4}$	0.7	2.5	——	——	——	——	——	——	——	——	——
tops.	1x3x$\frac{1}{16}$	1.3	6.0	35,000	——	16,000	8,000	——	——	——	——	——
ctrical reater so de-	1x3x$\frac{1}{4}$	0.7	4.0	37,000	25,000	19,000	9,000	500	0.045	0.065	5.0	6.0
main- emain varia- water ch as umps tc.	1x3x$\frac{1}{4}$	0.50	3.0	37,000	25,000	19,000	9,000	500	0.045	0.065	5.0	6.0
	1x3x$\frac{1}{4}$	1.5	6.0	36,000	25,000	19,000	9,500	425	0.055	0.10	5.5	6.5
ularly ed by	1x3x$\frac{1}{4}$	0.75	4.0	36,000	25,000	19,000	9,500	425	0.055	0.10	5.5	6.5
hings.	1x3x$\frac{1}{4}$	1.0	5.0	35,000	24,000	20,000	10,000	150	0.10	——	7.0	——
rs and nusual rength	1x3x$\frac{1}{4}$	1.7	6.0	38,000	26,000	20,000	10,000	150	0.10	——	7.0	——
	1x3x$\frac{1}{4}$	1.0	5.0	37,000	25,000	19,000	9,000	——	——	——	——	——

Fine Appearance Without Complications

Art is the systematic application of knowledge. An attractive appearance is created by the skillful use of simple rules

An Interview With
WALTER DORWIN TEAGUE
Industrial Designer

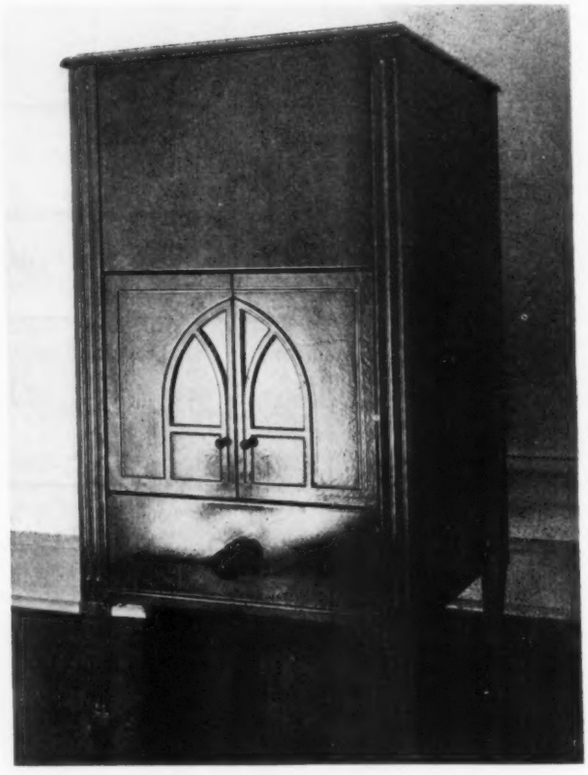
IT IS generally admitted that there is no longer any choice—the public demands an attractive appearance in products. George Eastman of Kodak fame summed up the situation tersely when he said, "For the past 50 years we have been learning how to make things. We have learned that quite well; now we can give our attention to making things beautiful." The age of utility in products is now superseded by the age of utility plus beauty. Products, particularly those for the home, must not only *be* efficient and well made, but over and above that the product must *look* finely built and efficient.

Perhaps no other single event in the history of American manufacture contributed more to bringing about a recognition of beauty value than Henry Ford's capitulation. When he discarded the famous utility car Model T and supplanted it with the Model A, American business was aroused to a realization of the importance of appearance. The automobile had definitely passed through the first two stages of its development—first, a car that could run; and second, a cheap car that could run. During these first two periods there was little opportunity to criticize or stress appearance. But when Henry Ford discarded his low-price utility model, it was equivalent to announcing to the world that its greatest automobile manufacturers definitely admitted that appearance had become the dominating factor in automobile sales. This impelled many other manufacturers to look into their products with reference to appearance. And many designing engineers were faced with a new problem.

Although it has only been within the past decade that the appearance factor was given its great impetus, appearance has always been an important factor. People must depend on what they see—seeing is believing. This has always been true, and always will be. Appearance is merely better recognized today; its value has been discovered.

It is unfortunate that the term "art" is so commonly associated with "prettifying" or decorating, a procedure which invariably results in gaudiness. Because of the wrong impression that a fine-looking product is the result of a deft manipulation of paint brushes and pencils, many engineers believe that a product can be made good looking only by a complete engineering redesign and the addition of numerous parts solely for decorative purposes. Such is far from the truth.

It is the business and responsibility of the true art designer to create a fine looking product that can be built by the existing personnel and equipment of the plant that is to manufacture the product. All processes of production available in that plant must be taken into account. If the company is equipped primarily for making castings, they should be used; if the factory is largely devoted to sheet metal working, stampings should be used. Similarly with reference to the type



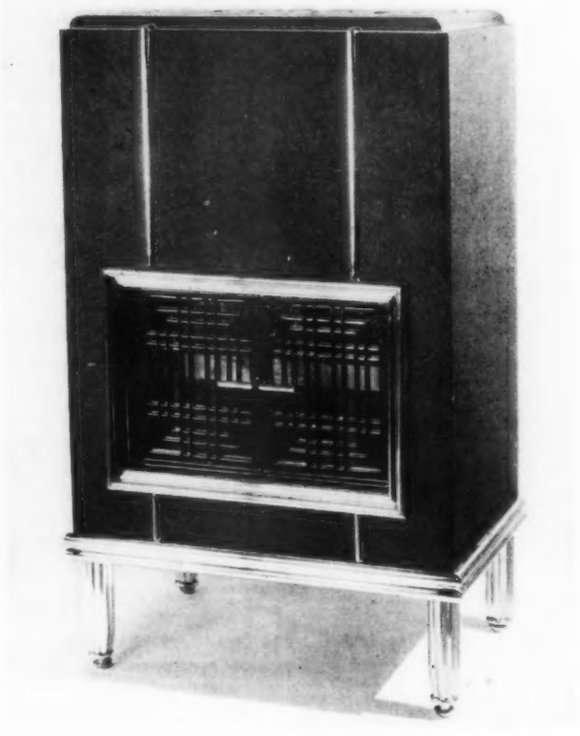
Oil-burning space heater of the American Gas Machine Company as it was before it was redesigned by Walter Dorwin Teague. It has a steel cabinet with an imitation wood finish.

of finish. The whole design must be in accord with the plant facilities. Beauty can be created equally well with any process.

The fundamental task of the artist designer can be summed up in the axiom that he must take what industry has available, know what to select and how to use it economically to achieve a product of pleasing appearance. An example of how this can be accomplished is shown in the illustrations of the new oil-burning heater manufactured by the American Gas Machine Company, Inc.

When Walter Dorwin Teague was called in to redesign and restyle this device he found a product that followed the traditional designs of the industry. These were an outgrowth from the old coal-burning stove with its ornate filigree work and dust-catching "trimmings." The newer oil-burning heaters attempted to imitate phonographs or radio cabinets in their appearance. Conforming to the custom, the steel cabinet had an imitation wood finish.

After a study of the situation Mr. Teague made two general recommendations. The first was that the new design of heater should conform to its function. Thus the new design was not to imitate a wooden cabinet, but, on the contrary, was to emphasize the fact that it was a steel box in which it would be perfectly safe to build a fire. The second recommendation, applicable to almost every product, was that the appearance of the heater should take it out of ordinary competition by making it look much more expensive and substantial.



Oil-burning space heater of the American Gas Machine Company after its redesign by Walter Dorwin Teague. The cabinet is finished in a dark-brown crystalline lacquer and chrome-plate

With reference to the type of construction, the new unit, like the design which it was to replace, was to be made principally out of gray iron castings and sheet steel. Because the old product had proved to be a highly efficient unit, there were to be no changes in its fundamental mechanical designs, or method of construction. Thus, all improvements in the appearance would have to be made through relatively simple changes and by strict attention to detail.

To achieve an impressive appearance of solidity and massiveness advantage was taken of the fact that these heaters have an inner and outer casing. By recessing the door in the front of the cabinet, the full depth between the inner and outer walls was disclosed. To emphasize this depth, the door is framed in heavy chromium-plated molding. Merely emphasizing this depth of construction gave an immediate impression of massiveness.

But there was one thing that gave the old design a "tinny" appearance. The raw edges of the steel sheets were visible at the joints. As long as such edges were visible, it would be futile to expect an appearance of sturdy construction. The problem then was to alter the panel construction so that the edges would be hidden.

This was accomplished by continuing the side panel around the front corners for a distance of 6 or 8 in. across the front. The joints between the center front panel and the side panels were then covered with a chromium-plated stock molding extending from the top of the door frame to the top of the cabinet and from the bottom of the door frame to the bottom of the cabinet. Not only does the chromium-plated molding serve as a decorative feature, but it also serves to tie the top and bottom moldings and door frame into one unit, making the front grille the center of attraction.

In the old design, the grille casting on the top of the cabinet overhung the side walls. The raw edges of the castings gave an impression of unfinished and cheap construction. In the redesign, the front and side panels are turned in at the top and the top grille casting is made slightly smaller than the top of the cabinet. The edges of the casting rest on the turned-in panels. This not only gives a cleaner and smoother appearance, but it also adds much to the impression of solidity and massiveness. Here also, as a decorative feature, the top casting is chromium plated around its edges. Chromium plating is also used to set off the molding around the bottom of the cabinet.

One poor feature of the old design was the adjustment of the legs. On all such heaters it is necessary to have some form of height adjustment for the legs in order to compensate for unevenness in the floor upon which the heater rests. In the old designs false legs were used and it was necessary to adjust their height by means of a screw driver, an extremely cumbersome operation. In this new design two changes in the legs were decided upon. A simple means for adjusting the height of the leg was to be provided, and, secondly, the false construction was to be eliminated. As can be seen in the illustration, the legs of the new cabinet are cast full height and rounded. A knurled wheel is near the bottom of each leg. This wheel is part of a stud

that threads into the cast leg. To adjust the leg height it is merely necessary to turn the knurled wheel. And this hand-operating leveling device looks like an integral part of the design.

In the new design not a joint, screw or bolt is visible anywhere on the cabinet. One unsightly feature of the old cabinet was the oil supply tanks mounted at the back. This problem was solved by Mr. Teague by inclosing the tank in a compact jacket with rounded edges and finished like the cabinet itself. Thus subdued, the oil tank does not detract from the appearance of the heater.

As mentioned, one of the fundamentals was to avoid an imitation finish, and above all, not to convey the appearance of building a fire in a wooden box. For this reason the former walnut imitation finish was replaced by a dark-brown Damaskene finish in lacquer. This finish not only withstands chipping and cracking but forms a beautiful background for the light and sparkle of the chromium-plated molding which frames the front grille door.

One is naturally interested in what the results of this redesign might have been. Quoting a report that appeared in *The Commercial West:*

"The new Teague-designed heaters simply took the trade by storm. They were so much more beautiful than anything in their class that the dealers had ever seen or dreamed of, that sales were easy. Orders came thick and fast. By September 1, twice as many heaters had been sold as were sold in the entire preceding year. The new heater line went over with a 'bang.' The only problem was the production of the new heaters in sufficient quantity to take care of the demand."

Elements of Streamline Sections

E. C. Hartmann
Aluminum Research Laboratories
Aluminum Company of America

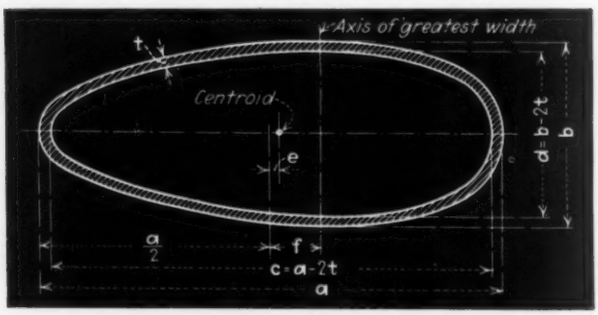
To use streamline tubing it is necessary to have the values of the cross-sectional area, least moment of inertia, least radius of gyration, and the location of the centroid.

If streamline tubing sections were simple geometrical shapes, the values of the cross-sectional area, least moment of inertia, least radius of gyration, and the location of the centroid could be calculated in the same manner as for round tubing, angles or channels. But, unfortunately, commercial streamline sections do not lend themselves to such treatment.

One of three methods may possibly be used in determining the elements of streamline sections. These methods are: (1) Tests on samples (2) Mechanical or longhand integration from carefully made drawings (3) Approximate formulas. An investigation of all of these methods made at the Aluminum Research Laboratories under the direction of R. L. Templin, chief engineer of tests of the Aluminum Company of America, showed that the use of approximate empirical formulas gave reasonable accuracy. It was found that values accurate to within two or three per cent were consistently obtained by calculating the moment of inertia as that of the least moment of inertia of an ellipse having the same wall thickness and major and minor axis as the section in question. This, however, did not give good check on the area of the section and it was decided to use the weight method to determine this value, a correction factor being applied to take into account the difference between the nominal dimensions of the section under consideration and those of the sample weighed. Satisfactory results were obtained. The value of the area as determined by weighing a sample was multipled by the ratio of the area of the equivalent elliptical section having the same nominal dimensions as the section in question to the area of the equivalent elliptical section having the dimensions of the sample weighed. The results obtained by this method will be always the same regardless of the dimensional difference in the sample.

From the area and the least moment of inertia, the radius of gyration squared will be the latter divided by the former. Location of the centroid, however, is more difficult. It lies on the axis of symmetry some place between the midpoint of the major axis and the point of greatest width of the section. An empirical relation was established for locating this position approximately. The distance from the midpoint of the major axis to the centroid was found to be approximately one-tenth the distance from the midpoint to the point of greatest width.

This method for determining the elements of sections of streamline tubing as developed by the Aluminum Company of America is summarized in the accompanying illustration and formulas. It should be pointed out that in addition to determining nominal elements, these formulas can also be used for determining the value for any particular sample if the dimensions of that sample are substituted for the nominal dimensions.



Cross-sectional area, sq.in. $= \frac{KW}{wL}$

where W = weight of sample of section in question, lb.,
L = length of sample, in.,
w = weight of material, lb. per cu.in.,

$K = \frac{(ab-cd)\ \text{(nominal)}}{(ab-cd)\ \text{(for sample)}}$

Least moment of inertia, in.^{4} $= \frac{\pi}{64}(b^3a - d^3c)$ (nominal)

Least radius of gyration, in. $= \sqrt{\frac{\text{Least moment of inertia}}{\text{Area}}}$

Distance, e, from midpoint of major axis to centroid $= f/10$.

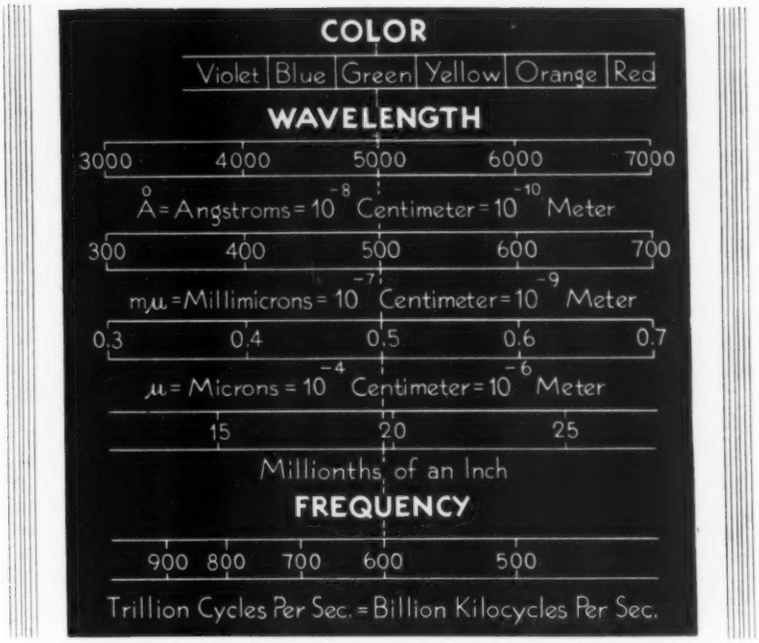


Fig. 1—Both wavelengths and frequencies in various units are used to designate color hues

Color Response of Photocells

Color response in photo-electric cells varies with the type of cell, the composition of the light sensitive surface, and the method of construction, as well as the three characteristics of color

R. C. HITCHCOCK
Electronics Engineer, Westinghouse Electric & Mfg. Company

CHARACTERISTICS of color and the properties of the photocell are both involved in the selection of the photocell and light source for applications wherein the cell response must be in proportion to the variations in the illumination on the cell. The color response of photo-electric cells varies with the type of cell, the composition of the light sensitive surface, and the method of construction, as well as the three characteristics of color: hue, value and intensity.

Hue distinguishes one color from another, as a red hue from a yellow one, and is measured in wavelengths and frequencies. The dotted line shown in Fig. 1 indicates a particular green hue whose wavelength can be stated in several units, each meaning the same hue: 5,000 Angstroms, 500 millimicrons, 0.5 microns, or about 20 millionths of an inch. Hues have frequencies as well as wavelengths, the green hue having a frequency of 600 trillion cycles per second.

Hues affecting the eye or photocell are either reflected or transmitted, the greatest reflectivity, specular reflection, being obtained from the metallic luster of a polished metal surface. A second type of reflection occurs when incident light penetrates a short distance into a pigment. In the light diffused out of the pigment, some hues are removed by absorption, and the color of the reflected light is thus made up of the incident colors not absorbed by the pigment. For example, if a ray of light containing all hues falls on a red pigment, the ray of light loses by absorption all but the red portion. If this illumination is replaced by light containing no red rays, no reflections will occur, so that all of the incident light will be absorbed and the pigment will then appear black.

In the amount of absorption at the reflecting surfaces is found the important difference between specular reflection, and reflection from pigments. Polished metal surfaces reflect 80 to 90 per cent of the incident light (*Product Engineering*, April, 1933, p. 137), while good colored reflectors, such as vitreous enameled sheets, reflect less than 10 per cent (*Product Engineering*, August, 1933, p. 311).

Transmitted light in contrast to reflected light has a

much wider range of intensity. Optical glass transmits more light with less absorption than is reflected by polished metal surfaces, and prisms are more efficient than mirrors for changing the direction of a light beam.

Value characteristic of color is the relation of a color to black and white. If white, which has a high reflection for all colors, is added to a prussian blue, the hue is still blue, but the color does not absorb green and red as strongly as before. A hue diluted by the addition of white is sometimes called a tint. In the other direction, addition of black to a hue produces a shade, decreasing the reflection of the pigment for all visible hues. The range from the lightest tint to the darkest shade is often referred to as the tones of a hue.

Intensity characteristics of color are of special interest in considering practical uses of photocells. The intensity of a color is based on a comparison of the color with a neutral gray, the gray being a properly proportioned mixture of a spectral color with its complementary color. The intensity of a color is controlled either by mixing the color with a neutral gray of the same value, or by mixing the color with a similar valued hue having more intensity.

In Fig. 2 is shown the average human eye response to visible color, ranging from 0.4 microns, violet, to 0.7 microns, red. The total eye response is made up of three separate color sensations, green, red and blue; but the blue response is less than 1 per cent of the other two. Adding the three responses gives the total response having a maximum in the green region, as shown by the solid line in Fig. 2.

Color sensitivities of five photo-electric cells are shown in Fig. 3. Curves *1* and *2* represent two types of caesium phototubes, the photo-emissive type. The selenium cell, or photo-conductive type, has a response typical of the curve *3*. Curves *4* and *5* are for photo-voltaic or dry-disk type. The response of the copper oxide cell is shown in curve *4* and in curve *5* is shown the response of the iron selenide disk.

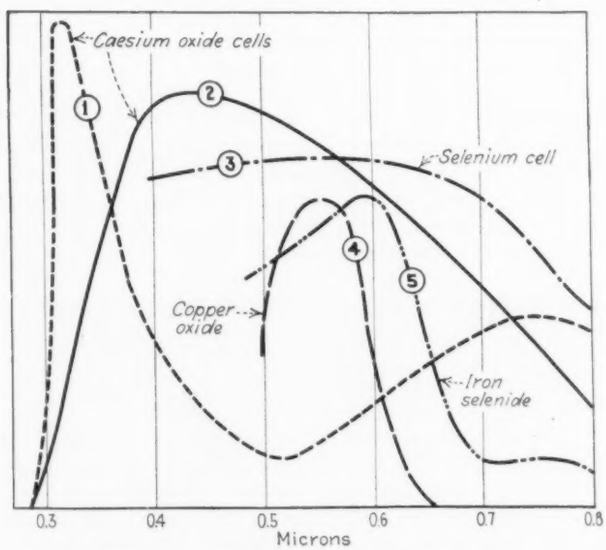


Fig. 3—Each type of photo-electric cell has a particular color response curve. Special manufacturing processes can provide still other types of response

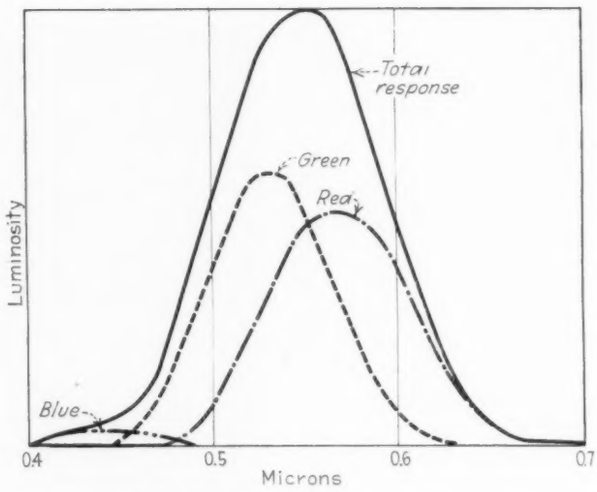
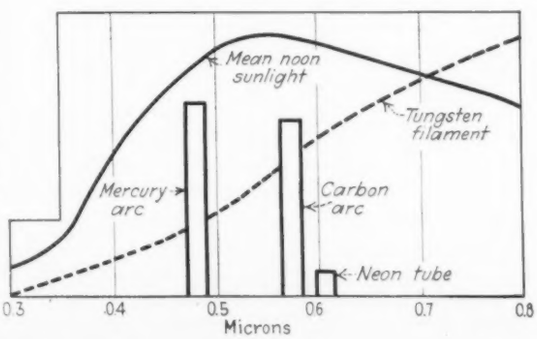


Fig. 2—Color sensitivity of the average human eye is greatest in the green and least in the blue, the peak of the total response corresponding to the peak in sunlight

From the wide variety of color responses found in photocells, it is apparent that the color emission of the light source is an important factor. As shown in Fig. 4, the curve for the color distribution in sunlight has a peak close to that of the peak in the response of the human eye. However, for practical use under varying weather conditions sunlight does not provide a uniform source of light for photo-electric devices. The best general source of artificial light is an incandescent lamp, but the color distribution in radiation from tungsten filament is of a different character from that found in sunlight. The dotted line of Fig. 4 shows the color radiation of a tungsten filament at 2,870 deg. absolute, showing the lack of blue and the gradual rise in the green to the highest point shown in the red. The maximum energy radiated by the filament is in the infra-red region, beyond the visible spectrum in the region sometimes termed invisible light, but better known as heat.

Color characteristics of the radiation from a tungsten filament vary with the temperature of the filament, which in the ordinary tungsten lamp is controlled by the voltage applied to the filament. A 2 per cent rise

Fig. 4—Each source of light has its particular color distribution. Sunlight and incandescent filaments both have strong radiation in the infra-red region



of the filament voltage may cause as high as 10 per cent increase in the light emission, and result in a shift of the maximum output from the infra-red toward the visible spectrum. For this reason, it is frequently desirable to use a voltage regulator on an incandescent lamp source supplying illumination for a photocell. Ballast tubes, saturated reactors and specially wound transformers are commonly used for voltage regulators.

As to other types of light sources, the mercury arc lamp radiates mainly in blue-green, its relative intensity to sunlight being shown by the height on the rectangle in Fig. 4. The carbon arc peak is nearer the red, and the radiation from the neon glow tube is shown in the small rectangle at 0.6 microns, in the red.

In selecting the light source for use with a given photocell any one of three combinations are possible.

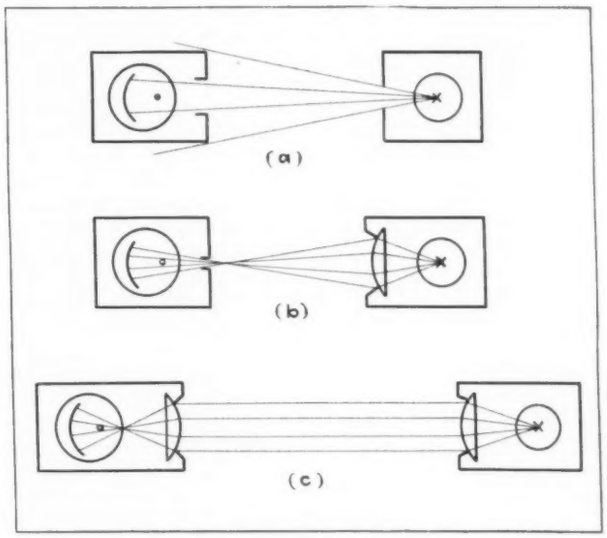


Fig. 5—The distance between the photocell and its light source is a consideration in the selection of the optical system

If a maximum response is desired without reference to hue, an incandescent lamp in combination with either the selenium cell or the caesium oxide phototube gives the largest response because of the high sensitivity of both of these cells to the red and infra-red which the lamp radiates most strongly. If a uniform response over the visible color range is desired, such as for a photo-electric color analyzer, the phototube selected should have a higher response in the color regions where the color distribution in the illumination is deficient. For this application, the caesium oxide phototube is well adapted for use with an incandescent tungsten filament. For a color response similar to the human eye, the copper oxide disk alone, or the iron selenide cell with a suitable filter can be used with a tungsten filament lamp. If mirrors or lenses are used in the optical system, their color reflection or transmission characteristics must also be taken into account.

In the use of a light source it is always necessary to provide sufficient intensity to operate the photocell. Lamps used without accessories follow the inverse square law of intensity—that is, at three times the distance from the lamp, the intensity is only one-ninth.

For short spacing, not more than a few inches, the arrangement shown in Fig. 5 (*a*) is satisfactory. The focusing projection system (*b*) is particularly useful for precision controls arranged so that the light interruption takes place where the beam converges. For long spacing the parallel beam system shown at (*c*) is necessary, and has the added advantage that the photocell can be aimed at the light source.

For relatively long distances between the light source and photocell a projection optical system has the further advantage that smaller incandescent lamps are needed. When lenses are used, a larger ratio of lens diameter to focal distance produces a greater intensity of light in the beam. Corrected lenses in conjunction with suitable apertures allow the projection of clearer cut images, but where an accurate image is not required, reflectors usually are preferable.

In all projection optical systems, the smaller the light source the better the image. Physics formulas for focusing are based on a point source, and the smaller the filament size, compared to that of the lens or reflectors, the more accurately can the beam be focused.

Concerning Alloy Steel Castings

According to a paper by A. W. Gregg, superintendent of the Bonney-Floyd Company, the production of alloy steel castings in the United States has shown a remarkable increase during the last fourteen years. In 1918 the tonnage of alloy steel castings was 4.7 per cent of the total tonnage of steel castings produced, and in 1931 was 17.4 per cent of the total tonnage of castings.

In the pearlitic and sorbitic classes of alloy castings the reasons for the introduction of alloying elements will usually group themselves under one or more of the following heads: (1) Increased strength for a given ductility. (2) Increased ductility for a given strength. (3) Increased resistance to wear and abrasion. (4) Increased toughness to withstand shock.

With ordinary carbon steel, increased tensile strength beyond about 100,000 lb. per sq.in. by increased carbon content and by quenching and tempering, results in brittleness and lack of ductility. This is of sufficient detriment to warrant the extra expense of an alloy addition. Conversely, carbon steel sufficiently ductile for most applications can be produced by proper heat-treatment and a low carbon content. But it is possible with alloy additions to equal the ductility of the carbon steel and at the same time practically double its strength.

The same possibilities obviously exist in designing steels for shock or wear resistance. In every casting application it is important to determine the most favorable compromise between toughness and strength. This together with a consideration of the cost factor should permit a decision as to the kind of alloy steel and kind of heat-treatment best adapted to the job in question.

The alloys in greatest favor for the production of the pearlitic and sorbitic classes of castings are five in number: (1) Nickel, (2) Chromium, (3) Molybdenum, (4) Vanadium, (5) Manganese.

COMMUNICATION and COMMENT

New Type of Magnetic Clutch

C. Q. PAYNE
New York, N. Y.

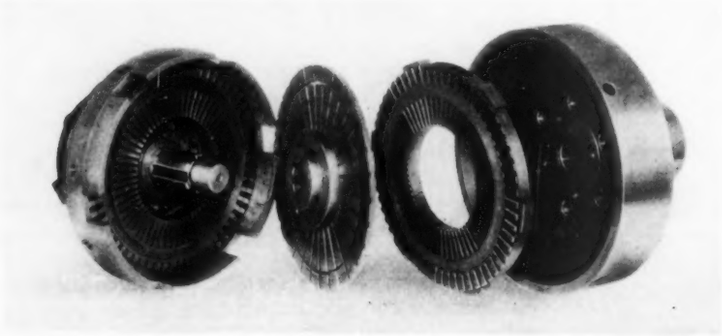
Magnetic clutches as heretofore designed have transmitted torque either wholly or partly through an air gap, or by direct contact between magnetized engaging members having smooth surfaces. The air gap clutch has the torque characteristics of a motor drive with its relatively large size and high cost, while in the direct contact clutch the coefficient of friction and pull-out torque vary with the condition of the surface.

The clutch shown in the illustration uses a new principle of engagement for the magnetic clutch faces in direct contact. Variable friction is overcome by a large part of the tractive force of the electro magnet being exerted as a torque. This is accomplished by the radial slots cut in the engaging faces, the slots varying the magnetic reluctance of the flux circuit as the engaging members move relatively to each other.

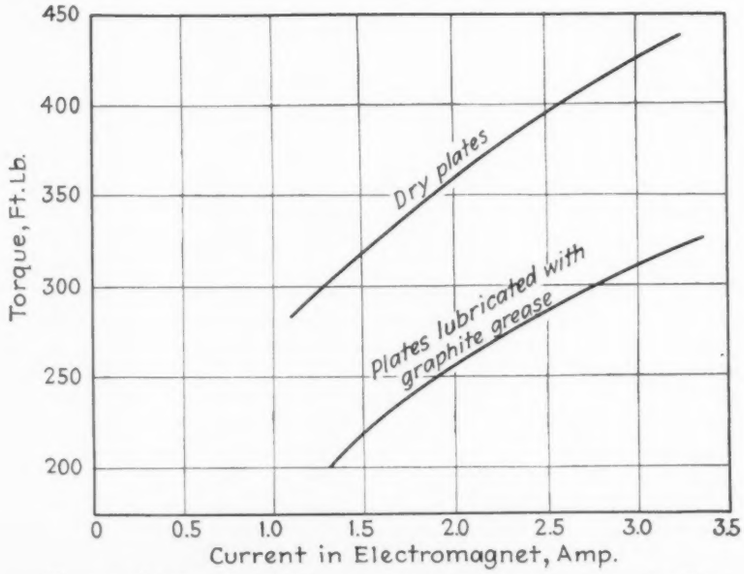
To provide smooth engagement of the clutch, a disk-plate forms the driven member and floats freely between the faces of the electro-magnet and its armature plate. In disengaging, the armature plate is retracted axially a short distance from the disk-plate by a spring, while the disk-plate moves slightly on its splined shaft clear of the electromagnet.

The illustration shows the elements of a small clutch of this type designed as a cut-off coupling for general industrial applications. Sixty grooves are cut in the faces of the armature plate, alternate grooves registering with 30 grooves in the disk-plate. The ungrooved pressure area of bronze is inserted between the pole faces to distribute the engaging pressure over a greater surface than the torque areas. Then, to compensate for the metal removed from the grooves, the combined pole-face areas of the clutch are made about twice that of the core areas of the electromagnet.

The design illustrated has a clutch face 8-in. in diameter, and weighs 34 lb. The electrical energy required to develop a torque of over 400 ft. lb. is 15 to 18 watts, only 2½ to 3 amp. from a 6-volt storage battery. Only half of this energy is required for gradual engagement. Since no friction material is used in this construction no adjustments are necessary to take up wear, and the torque is not greatly affected by the presence of lubricants. As shown in the curve based on tests results obtained at an eastern university, the torque is reduced only about one-quarter when a graphite lubricant is used on the clutch faces.



High capacity of this magnetic clutch is obtained by converting tractive force into torque resistance



Since no friction material is used the clutch can be operated with a lubricant between the contacting faces

Photo-Controls for Weighing

To the Editor:

Regarding the applications of photocells to weighing devices as described in the article apearing on page 345 of the September *Product Engineering*, we have found that the use of the

photo-emissive type of photocell is desirable because of the high-speed response necessary to secure accurate results. Sufficient current is supplied by the photo-emissive type of photocell, when used with an amplifying type, to operate a high-speed mechanical relay having comparatively small inertia. The action of this relay and photocell combination is so fast that the response to a change in light intensity is almost instantaneous.

With the light from a 15 cp. automobile-type lamp directed upon a photo-electric tube by a lens system, a comparatively simple circuit will supply to the relay a current of 10 milliamperes or more. When the light to the cell is cut off the current drops to about 50 microamperes. There are several sensitive relays on the market that will pull in at approximately 2 milliamperes and drop out at 1.5 milliamperes. Using this combination of photo-emissive cell, amplifying tube and sensitive relay, the input voltage on the supply circuit can be lowered from a normal 115 volts to as low as 90 volts, or raised to 140 volts without affecting the operation of the sensitive relay. If the voltage drops to 90, the operating current through the sensitive relay will not fall below 4 to 4.5 milliamperes, and if the voltage is raised to 140, the dark current passing through the sensitive relay will not be more than 0.5 milliampere, so that under these extreme conditions, the relay operates satisfactorily. Since this wide variation in voltage is allowable, it is necessary to make only infrequent adjustments in order to take care of changes in tube characteristics. For the same reason, the ordinary changes in temperature will have little or no effect on operation. In installations where voltage may fluctuate beyond the range between 90 to 130, the addition of a standard voltage regulator will allow line voltages varying from 60 to 160 volts.

The only place where current leakage or capacity has any effect on such a circuit is in the leads from the control panel to the photo-electric cell when the cell is remotely placed. By placing the two leads to the photo-electric cell in separate conduits, successful operation has been obtained with the photocell at a distance of 75 ft. from the amplifying tube.

Since the photo-emissive cell and amplifier tube combination supplies a greater amount of current to the sensitive relay than is supplied by the dry-disk photocell, there is a stronger magnetic pull holding the relay in the "on" position, and vibration has less effect on the operation. This effect has been found to be of importance in several installations where considerable vibration was encountered.

In order to obtain an accurate cut-off point with the photo-electric control, it is necessary to direct the beam from the light source in such a manner that it converges in a space $\frac{1}{16}$-in. wide and 1-in. long, the dimensions of the slit in a mask over the photo-electric cell. After passing through the slit the beam again diverges to cover the sensitive element of the photocell. Since the slit is about the same shape as the sensitive element the entire sensitive surface is covered when this type of light system is used. With the dry-disk cell in which the sensitive element is circular in shape, an even distribution of the light over all of the sensitive face is extremely difficult to obtain.

In about 70 installations cut-off scales are controlled by devices using the photo-emissive type of photocell, and entirely satisfactory results are being obtained. —M. A. WECKERLY
Engineer, Toledo Precision Devices, Inc.

Angle ε for Circular Cutters

Number of Teeth in Cutter	14½ deg. pressure angle	20 deg. pressure angle
80	15 deg. 19 min. 36 sec.	21 deg. 31 min. 3 sec.
64	15 " 28 " 31 "	21 " 42 " 0 "
48	15 " 44 " 42 "	22 " 1 " 4 "
40	15 " 57 " 49 "	22 " 17 " 0 "
32	16 " 19 " 14 "	22 " 42 " 53 "
24	16 " 57 " 46 "	23 " 25 " 53 "
20	17 " 30 " 52 "	24 " 3 " 5 "
16	18 " 23 " 50 "	25 " 1 " 50 "

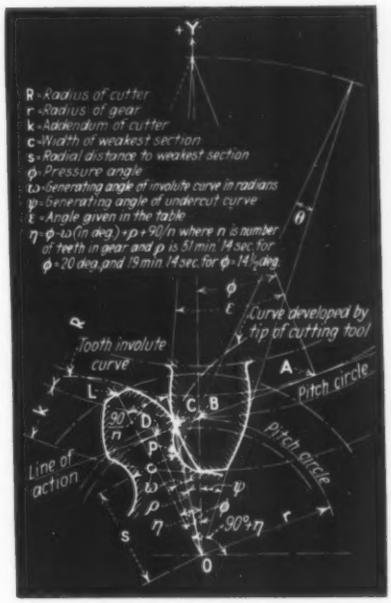
Undercut Gear Teeth

To the Editor:

As shown in an article appearing on page 265 of the July *Product Engineering*, hob-cut gears with less than 37 teeth are undercut when a 14½-deg. pressure angle is used. When a 24-tooth circular cutter is used, gear teeth are undercut when the number of teeth is less than 26 for a 14½-deg. pressure angle, or less than 16 for a 20-deg. pressure angle.

When using a circular cutter, the size and location of this undercut portion can be determined by applying the same analysis to this problem as was given for the hob-cut teeth. The distance *CB* in the accompanying diagram is given by the Equation (1) using terms as defined in the diagram. With *DB* known, the angle ω in the triangle *DOC* is obtained from Equation (2).

As in the solution for the hob-cut gears the equations for the curve developed by the tip on the cutting tool is found by superposition to be as shown in Equations (3) and (4). The shortest distance between this curve and the center line *OL* is at the point



$$CB = R(\varepsilon\cos\phi - \sin\phi) = r(\sin\phi - \omega\cos\phi) \quad (1)$$

$$\omega = \frac{r\sin\phi - R(\varepsilon\cos\phi - \sin\phi}{r\cos\phi} = \tan\phi - \frac{R}{r}(\varepsilon - \tan\phi) \quad (2)$$

$$x = (R+r)\sin\psi - (R+k)\sin\left(\frac{r+R}{R}\right)\psi \quad (3)$$

$$y = (R+r)\cos\psi - (R+k)\cos\left(\frac{r+R}{R}\right)\psi \quad (4)$$

$$z = \left(\frac{R+k}{R}\right)\sin\left(\frac{r+R}{r}\right)\psi - \sin\psi + \left[\cos\psi - \left(\frac{R+k}{R}\right)\cos\left(\frac{r+R}{R}\right)\psi\right]\cot\eta \quad (5)$$

$$c = 2(y_0\sin\eta - x_0\cos\eta) \quad (6)$$

$$s = x_0\sin\eta + y_0\cos\eta \quad (7)$$

Dimensions of the undercut section are given by these equations for teeth cut by a circular cutter

P where a tangent to the curve is parallel to *OL*. Setting up the equation of the tangent, differentiating and substituting as in the former solution gives Equation (5). This equation is solved by trial, finding the angle that makes *z* equal to zero. Substituting

this angle in Equations (3) and (4) gives the x and y coordinates of the point of tangency.

With the point of tangency known, the width of the weakest section c, and its distance from the center of the gear s, is determined from Equations (6) and (7).

For a 6-tooth and 2 diametral pitch, 20-deg. pinion cut by a 16-tooth circular cutter, ϵ is 25 deg. 1 min. 50 sec., r is 1.5, η is 26 deg. 8 min. 12 sec. Solving Equation (5) by trial gives ψ = 18 deg. 28 min. 56 sec. Substituting this value of ψ in Equations (3) and (4) gives the coordinate of the point of tangency P as $x_o = 0.2214$ and $y_o = 1.0808$. Using these values in Equations (6) and (7) shows that $c = 0.5546$ and $s = 1.0640$. A comparison of these dimensions with the dimensions of the undercut section obtained with hob-cut teeth indicates that the circular cutter produces somewhat stronger teeth. —H. SCHAFER
Philadelphia, Pa.

Triangle Problem

In the October *Product Engineering* C. W. Hinman asked for the dimension between two guide pins forming the base of an isosceles triangle with 20-in. sides, circumscribing a 9-in. square. From the large number of contributions received, the five solutions given here were selected as representative of the different methods of attack. The first three, involving a fourth power equation, are in agreement to the third decimal place. The last two are cut-and-try solutions and show that such methods must be handled with considerable care to obtain the accuracy given by the analytical methods.

None of these five solutions indicate that there are two base dimensions that satisfy the conditions of the problem. Several contributions to be included in the January number give both of these base dimensions.

To the Editor:

Using the point O in the diagram as the origin of a coordinate system, the general equation for the lines CD and CA are:

$$\frac{x-a}{c-a} = \frac{y}{d} \qquad \frac{x-a}{a} = \frac{y}{b}$$

Eliminating x and y from these two equations gives the relation $(c-a)/d = -a/b$. But $b^2 = e^2 - a^2$, so that the general relation becomes:

$$a^4 - 2ca^3 + (c^2 + d^2 - e^2)\,a^2 + 2ce^2a - c^2e^2 = 0$$

Substituting the dimensions given in the problem into the general relation gives:

$$a^4 - 9a^3 - 298.75a^2 + 3600a - 8100 = 0$$

From a layout the value of 9 is a first approximation for a. Using Newton's method the error is +0.096. With a second approximation of 9.096 the error becomes +0.000095, so that the third approximation for a is 9.096095. The base of the triangle BC is therefore 18.19219 in.

—HANS SCHEMM
Philadelphia, Pa.

To the Editor:

Referring to the accompanying figure, two equations in x are obtained.

$y/9 = (y + 9)/2x$ or $x = (9y + 81)/2y$
and $x^2 + (y + 9)^2 = 400$

Substituting the value for x into the equation for x^2 and simplifying gives:

$$y^4 + 18y^3 - 298.75\,y^2 + 364.5y + 1640.25 = 0$$

When this equation is solved by Newton's method, the root y is 8.81185; and substituting this value of y in the first equation for x gives a value of 9.09608. The base of the triangle is therefore 18.1922 in.

—C. A. WIKEN
Rockford, Ill.

To the Editor:

In the accompanying diagram a value for y in terms of x can be obtained by setting up the following two equations for the area of the triangle ABC.

$$\tfrac{1}{2}(9 + y)(9 + 2x) = \tfrac{1}{2}(9y + 18x + 2xy + 81)$$

$$9y/2 + 9x/2 + 9x/2 + 81 = \tfrac{1}{2}(18x + 9y + 162)$$

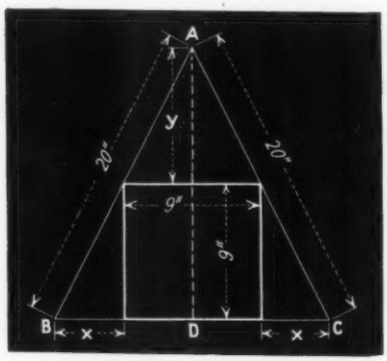
From these two equations, $y = 81/2x$. Also from the triangle ADC another relation between x and y is obtained:

$$(y + 9)^2 + (x + 9/2)^2 = 400$$

Substituting the above value for y in this equation, and expanding gives the equation:

$$4x^4 + 36x^3 - 1195x^2 + 2916x + 6561 = 0$$

Solving for x by means of synthetic division gives a value of 4.596 for x. The base of the triangle is then 18.192 in. —L. J. CAVAGNET
New York, N. Y.



Relations involving the area of the triangle are used by Mr. Cavagnet to obtain the base dimension

To the Editor:

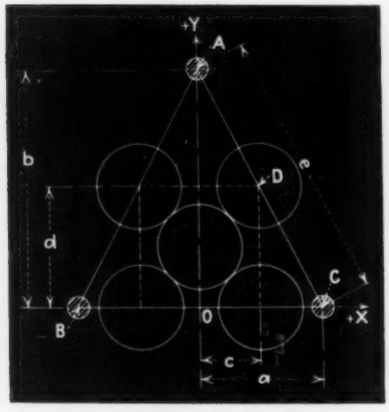
Referring to the figure, the relation between x and y can be set up in terms of the angle ϕ as follows:

$$9/\cos\phi + 4.5/\sin\phi = 20 \qquad (1)$$

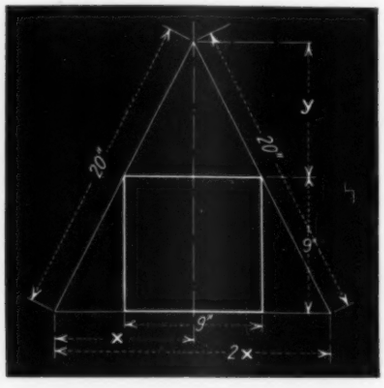
This equation can be converted into an equation with one unknown, sin ϕ, but in the form of a bi-quadratic equation requiring tedious calculations in solving. But Equation (1) can be rewritten into the form:

$$2\sec\phi + \csc\phi = 4.4444 \qquad (2)$$

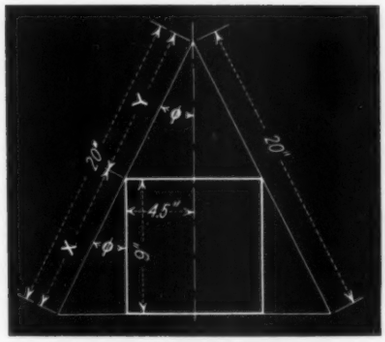
By a cut-and-try method of substituting values for ϕ in Equation (2)



A general solution for the base of an isosceles triangle circumscribing a square is given by Mr. Schemm



An equation for the base of the triangle is obtained from the given relations by Mr. Wiken



In solution submitted by Mr. Johnson and Mr. Prion, cut-and-try methods give results which vary in the third decimal place

the angle of 27 deg. 2 min. is found to satisfy the equation to three decimal places. The base of the triangle then is 40 sin ϕ or 8.1908 in.

This cut-and-try method is useful in solving many problems of this type. If the terms of the equation have coefficients with several decimal places, a slide rule can be used until the required angle is approached and the procedure continued by longhand or on a calculating machine to the required number of decimal places.

—JOHN E. PRION
Pittsburgh Gear & Machine Co.

To the Editor:

The length of the 20-in side of the triangle can be expressed in terms of the angle ϕ, shown in the diagram.

$$4.5/\sin\phi + 9/\cos\phi = 20$$

By a cut-and-try process the angle ϕ that meets the conditions of the equation is found to be 27 deg. 3 min. 8 sec. The base of the triangle is, therefore, twice 20 sin ϕ, or 18.1921 in.

—C. A. JOHNSON
Providence, R. I.

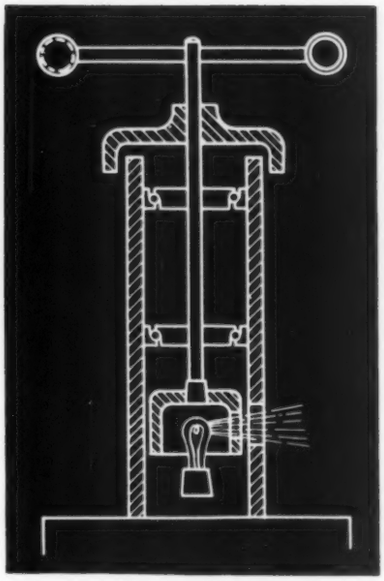
Correction

On page 429 in the November number, following the article "Photo-Electric Counting Device" the name of the author, Joseph Waitkus, New York, N. Y. was inadvertently omitted.

Substitute for Cocobola

C. F. SCRIBNER
Hendersonville, N. C.

Screwdriver handles, formerly made from imported cocobola, are now satisfactorily made from native hickory. The handles are turned and then soaked for several hours in a hot, red dye. After drying on wire screens and polishing with wax, the handles take on an excellent appearance. A pleasing striped effect is produced by the difference in density of the spring and summer growth.



Mounted on a parapet wall, the anemometer sends a light beam to a photocell inside the building. Rotation of the shutter interrupts the light, and operates a frequency meter

New Autoclaves

To the Editor:

Referring to an article in your November issue headed "New Standards for Precision Devices" with the subheading "Hospital Equipment," apparently this was published without full information being at hand as the article describes what is supposed to be a new design of sterilizer. Please refer to the inclosed reprint dated April, 1919 and you will quickly see what we have in mind.

—L. L. LUNENSCHLOSS
Vice-President, Scanlan-Morris Company

The reprint referred to, dated April, 1919, gave a description of the Scanlan-Morris high-pressure dressing sterilizer equipped with a steam generator. The subject matter of the article referred to tests conducted at the University of Wisconsin on these sterilizers to show the necessity of freeing the autoclave chamber of air. In the design referred to, this was done by an automatic air and condensation ejector in the air and condensate discharge line from the sterilizing chamber. The results of the test as reported clearly indicated that the automatic air-condensation ejector worked admirably and markedly increased the efficiency of sterilization.

The sterilizer described on page 416 of the November *Product Engineering* was a new design of the American Sterilizer Company, the feature of which design was the thermostatically controlled air valve in the discharge outlet leading from the bottom of the sterilizing chamber.

The description as given in *Product Engineering* expressly refers to the particular product described, and emphasizes the point that a thermostatically controlled air valve increased the efficiency of the operation of this sterilizer. That other sterilizers use equivalent devices is not surprising and we take pleasure in calling this fact to the attention of our readers.

Photo-Electric Anemometer

To the Editor:

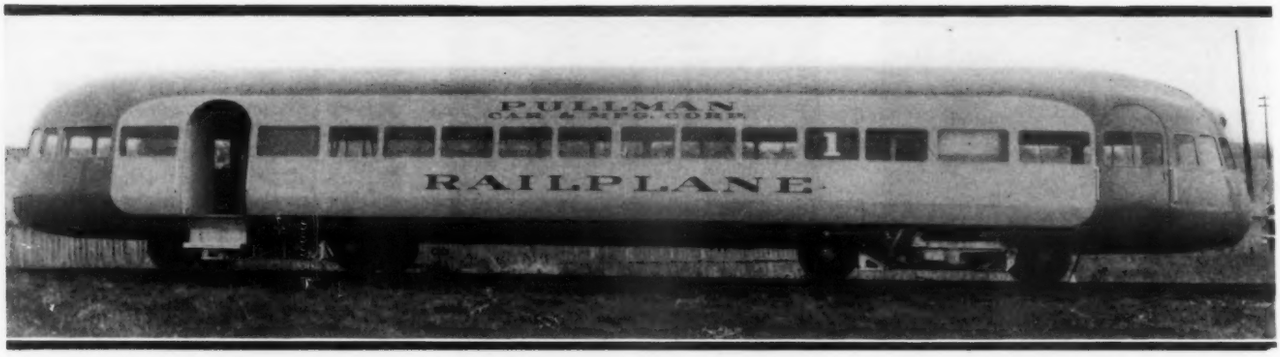
Illustrating one of the fields of application for photo-electric devices, the friction load imposed by a commutator on the shaft of an anemometer is eliminated by replacing the commutator with a rotating shutter. As shown in the illustration, light is directed on a photocell from a 6-volt radio dial lamp mounted inside the shutter and lighted from a bell-ringing transformer. With the photocell and amplifier placed indoors there are no contacts, commutators or mechanical drives exposed to the weather, and the light beam imposes no load on the anemometer. Sensitivity is further increased because the heat from the lamp keeps the bearing lubricant from congealing, and prevents condensation of moisture on the bearings. —C. W. HOUGH
President, Wired Radio, Inc.

Shrink-Fit Fastenings

To the Editor:

Shrink-fit fastenings, as outlined by Mr. Foreman in the August number and criticized by Mr. Shaw in the October number, have no particular value so far as easier removal and replacement is concerned, but there are many places where replacement would hardly be a factor, and in such designs fastenings of this type would certainly be practical.

It is interesting to note that refrigeration is being used to make expansion fits, even as heat is used for shrink fits. Conceivably in fastenings using a reverse taper fit a greater size differential could be used without heating the outer member so near to the melting point by refrigerating the inner member. It would be interesting to know if this has actually been done. —JOHN E. HYLER
Peoria, Ill.



Running tests indicate that this streamlined Railplane will contribute to the new era in transportation

NEWS

Railplane Makes 70 m.p.h.

On a 154-mile test run between Detroit and Delta, Ohio, over the tracks of the Detroit, Toledo & Ironton Railroad, the "Railplane," designed by William B. Stout for the Pullman Company, was given its first comprehensive test. With the throttle slightly more than half open, a speed of 70 m.p.h. was attained in spite of the fact that the road bed was not in the best condition. At this speed the engine was turning at 1,400 r.p.m., its maximum speed being 2,200 r.p.m.

According to Mr. Stout, "The new coach will go over 90 miles an hour without straining. But we are breaking it in as you do a new automobile."

On the basis of data obtained in these tests, it is expected that the Railplane can be operated at a passenger rate of one cent per mile.

A.I.E.E. Convention

Electric welding and electric furnace design will be discussed at two sessions of the American Institute of Electrical Engineers convention on January 24. A session on January 25 will be devoted to the design of electrical machinery.

New Life-Saving Device for Airplanes

The first public demonstration of a device to automatically launch passengers from an airplane in flight was demonstrated recently at Roosevelt Field, L. I. To three men and a woman go the honors of being the first ones to experience this new kind of forced landing.

In its operation, small doors in the cabin of the plane slide open when the pilot pulls an emergency lever. The passenger's seat turns its back toward the opening and as it does so engages an arm or small davit which thereafter supports the weight. The davit swings out and back, and the passenger, strapped in a deep rubber-cushioned chair, slides out through the opening. At the end of the range of travel a cam is tripped and the chair and occupant drop earthward. Simultaneously, a thirty-foot parachute opens and the chair with its occupant suspended from the parachute floats to the ground.

According to the reports of the demonstration, there is only a slight shock when the parachute first opens. In the public demonstration given, the plane was cruising at a speed of about 100 m.p.h. at an altitude of 1,500 ft. when the first passenger was ejected. It was a complete success.

According to Mr. Trusty who designed this device, the average rate of the descent is 9 ft. per sec. The shock on landing is considerably reduced by 3 in. of sponge rubber cushion in the seat of the chair. A further development of this device, which is now nearing completion, is a design of chair equipped so that it will sustain 500 lb. on the surface of the water. It is expected that these devices will find use not only for life saving purposes but also for delivery of mail and express packages.

Teague to Address Mechanical Engineers

Because of the great interest in product appearance, one of the papers to be presented at the machine design session, Tuesday, December 5, at the annual meeting of the A.S.M.E., will be on this subject. Walter Dorwin Teague, one of the foremost industrial artists, will address the meeting on the subject "Appearance in Design." His talk will be illustrated with lantern slides showing products that have been redesigned primarily to get a better appearance.

Mr. Teague is a contributor to *Product Engineering* and in this number appears the report of an interview with him wherein he sets forth some of the fundamentals that must be taken into consideration when redesigning a product for the purpose of obtaining a good sales appearance. It is extremely fitting that this initial machine design session at an annual A.S.M.E. meeting should be featured by an address on the subject of appearance by one who is recognized as a leader in this field.

New Low-Cost Rail-Car

Three companies, Fairbanks-Morse, Chrysler and Goodyear Rubber have jointly developed for railroad use a new design of rail-car to primarily compete with bus and truck traffic. This car is designed for branch line service and short hauls. Its principal features are that it is cheap, has low operating cost and a reasonably high speed. This last presented no special problem because the signal-protected right-of-way of the railroads makes it possible to operate vehicles at higher speed than is allowable on public highways.

Instead of concentrating on a brand-new product, the engineers built this new car as a modified truck chassis, with a modified body. A trailer can also be attached. In the design of the

chassis it was merely necessary to change the standard stub-type of front axle into a one-piece non-steering front axle. The Goodyear design of rubber tired wheel (see p. 446) is used. Other than that, standard automobile construction is used throughout.

A.S.M.E. Annual Meeting

In the session on Mechanical Springs to be held December 7 during the A.S.M.E. Annual Meeting, a paper on stress analysis in helical springs by H. C. Perkins, Cornell University and another on the effect of eccentric loading in helical springs by J. B. Reynolds and J. F. Houser, Lehigh University, are devoted to design problems. A report on recent developments in his investigation of elastic behavior and creep will be given by M. F. Sayre.

The Railroad Session on December 5 includes a discussion by E. E. Adams, vice-president of the Pullman Company, on light-weight rail-car development, a subject of timely interest in view of the developments as reported in recent numbers of *Product Engineering*. The Foundry Session on December 6 has arranged for a paper on welded joints by Everett Chapman. Other engineering design problems are discussed in two sessions on December 7, one conducted by the Aeronautic Division, and one under the auspices of the Applied Mechanics Division.

Magnetic Testing Being Widely Adopted

First introduced about eleven years ago, the iron filing method of locating physical defects in steel parts has been developed from a laboratory procedure to a routine commercial test. This development has been brought about largely through the work of The A. V. DeForest Associates. Their Magnaflux test eliminates the oil bath with its iron particles in suspension. In this test method as finally developed it is merely necessary to dust the magnetized part with a specially prepared iron powder. Soft iron or steel pieces must be kept in a magnetic field, while hardened steel parts can be previously magnetized, having sufficient residual magnetism for the test.

Because it is rapid and non-destructive, the Magnaflux method of testing for defects at or near the surface is being specified for various purposes. The Wallace Barnes Company adopted this method for detecting quenching cracks, seams and surface defects in steel springs. Other companies are specifying this method for detecting corrosion or fatigue cracks, faulty welds, and similar defects lying near the surface. Magnaflux testing is now also used by Naval aircraft inspectors stationed at manufacturing plants as well as in the plants of the Navy.

As the only material required by the test is the specially prepared iron powder, and as this can be collected and used over again indefinitely, no appreciable expense for material is involved.

Welding Society Holds Meeting on Aluminum

Much practical information on the aluminum, its properties, mechanical workability and fabricating characteristics was contained in three papers presented at a meeting of the New York Section of the American Welding Society held on Nov. 22, at the Engineering Societies Building.

The outstanding and special properties of aluminum and aluminium alloys and their characteristics were discussed by Dr. H. V. Churchill, chief chemist of the Aluminum Company of America. Although this paper was described as being non-technical, it is only fair to state that the information as presented by Dr. Churchill in a clear, simple manner has a direct bearing on the work of the designing engineer. The paper included a summary of the factors that enter into the mechanical workability of the metal and the characteristics that give it its wide range of possible applications.

Under the title of "Arc Welding and Electric Resistance Welding of Aluminim," D. I. Bohn of the Aluminum Company of America explained in considerable detail the weldability of aluminum and alloys by the electric processes. G. O. Hoglund of the same company discussed the gas welding problem in a paper entitled "Gas Welding of Aluminum."

In addition to the papers, there was a novel exhibit of modern aluminum products which added considerable interest to the meeting.

MEETINGS

American Society of Mechanical Engineers—Annual meeting, Engineering Societies Building, New York, N. Y., Dec. 4-8. Ernest Hartford, assistant secretary, 29 West 39th St., New York, N. Y.

Society of Automotive Engineers—Annual motor show dinner, Jan. 8. Annual meeting, Book-Cadillac Hotel, Detroit, Mich., Jan. 22-25. John A. C. Warner, secretary, 29 West 39th St., New York, N. Y.

American Institute of Electrical Engineers—Winter convention, Engineering Societies Building, New York, N. Y., Jan. 23-26. H. H. Henline, secretary, 33 West 39th St., New York, N. Y.

American Society of Heating and Ventilating Engineers — Annual meeting, Biltmore Hotel, New York, N. Y., Feb. 5-8. A. V. Hutchinson, secretary, 51 Madison Ave., New York, N. Y.

EXHIBITIONS

Fourteenth Exposition of Chemical Industries—Grand Central Palace, New York, N. Y., Dec. 4-9. Charles S. Roth, manager, Grand Central Palace, New York, N. Y.

National Automobile Show — Grand Central Palace, New York, N. Y., Jan. 6-13; Coliseum, Chicago, Ill., Jan. 27-Feb. 3. Alfred Reeves, manager, 366 Madison Ave., New York, N. Y.

Exhibition of Heating and Ventilating Equipment — Grand Central Palace, New York, N. Y., Feb. 5-9. A. V. Hutchinson, secretary, 51 Madison Ave., New York, N. Y.

Changes in Materials for Airplanes

Elimination of aluminum castings in favor of aluminum forgings and the use of magnesium castings in place of aliuminm castings, is finding considerable favor in airplane design. It is reported that one of the largest builders of airplanes is following a definite program in this direction.

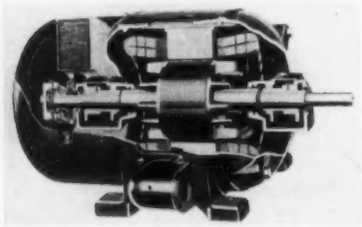
Small blow holes exposed after the machining operations on aluminum castings causes the rejection of an appreciable number of them. This involves a considerable loss. For example, the United States Navy will reject any part because of the presence of blow holes even when the location of the blow hole is such that its presence can do no apparent harm, such as a blow hole at the bottom of a blind drilled hole. The use of aluminum forgings in place of aluminum castings avoids such losses, more than compensating for the increased material cost.

With reference to the strong trend toward magnesium, this is, of course, based upon the saving in weight that results from the use of magnesium in place of aluminum. Roughly, based upon the relative densities of these two materials, 33 per cent weight is saved when using magnesium alloys in place of the aluminum alloys.

NEW MATERIALS and PARTS

Louis Allis Self-Contained Capacitor Motor

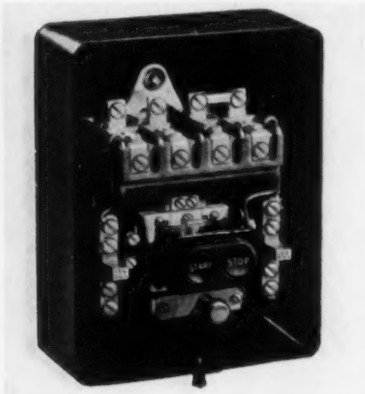
Available in sizes from ⅓ to 3 hp., horizontal or vertical mountings. Capacitor start, single-phase motor has cast iron frame and end brackets.



Specially treated windings have leads for 110 or 220- volt line. Direction of rotation of dynamically balanced rotor can be changed by interchanging leads. Capacitor is ring-shaped, of dry electrolytic type designed to eliminate high potential spots and give maximum radiation, mounted within the end bell extension. Motor cooling air passes between the condenser and motor. Centrifugal cut-out switch is said to be unaffected by variation in voltage or starting load, and to be free from radio interference. Removable cover designed to give accessibility to switch and condenser. The Louis Allis Co., Milwaukee, Wis.

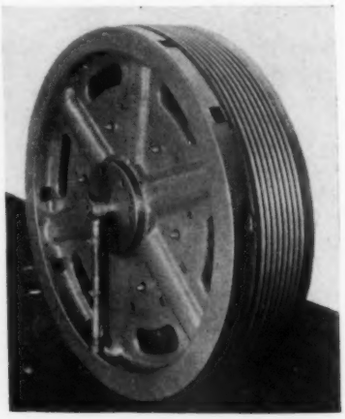
Allen-Bradley Automatic Switch

This solenoid-operated, across-the-line starting switch is available in three forms: with start and stop pushbutton, without pushbutton for thermostat or remote pilot control, with 2-way switch for "try-out" control. Overall switch dimensions are 8⅜-in. high, 6⅜-in. wide, and 3⅝-in. deep, with reset button extending ½ in. through the cover. Adequate wiring space is said to be provided in the small cabinet by reducing the size of switching mechanism. Double-break silver alloy contacts are claimed to reduce contact maintenance, and arc suppressors are said to be capable of breaking locked rotor currents of several times the rating of the switch. Overload protection is provided by two interchangeable thermal elements. All switch parts are mounted on the back plate with rubber grommets between the switch mechanism and the plate. Rated at 5 hp. 220 volts; 7½ hp., 440-550 volts for polyphase motors, and up to 1¼ hp., 110 volts; 3 hp. 220 volts for single phase self-starting motors. Allen-Bradley Co., 1311 South First St., Milwaukee, Wis.



Ajax Air Clutches

Are quick-acting, multiple-disk pneumatic operated clutches for use on forging machines, presses, bulldozers



and similar equipment. Pressure is applied to the friction surfaces by introducing compressed air behind an annular piston acting directly upon the friction plate. The only other operating parts are compression springs for retracting the piston and disengaging the plates when air pressure is released. Quick response and low air consumption is said to result from small clearance volume and short piston stroke of ⅛ in. on the four-surface, and 7/32 in. on the six-surface clutches. The clutch is operated by a two-way air valve. Pressure application to the friction plates during engagement is said to result in a cushioned acceleration. Designed so that anti-friction bearings carrying the flywheel and driving parts are not subject to thrust loads. Driving disks are of alloy cast iron with external cut teeth meshing with internal teeth in the housing. Driven disks are of steel plate with internal teeth meshing with a steel pinion on the clutch shaft. Available in sizes with friction plate diameters of 18 in., 21 in., 24 in., and 30 in., with capacities from 100 hp. to 1,000 hp. per 100 r.p.m. The Ajax Manufacturing Co., Cleveland, Ohio.

Zialite Nickel-Plating Process for Zinc

Makes use of a plating solution said to retard dissolving of zinc. Satisfactory nickel plate of thickness up to 0.002 in. or heavier is said to be possible using normal current densities, and the usual nickel-plating procedure required for articles of brass. It is claimed that the absence of black deposits and the formation of a denser grain structure in the plate makes it less subject to weathering and makes an excellent surface for chromium plating. Tuttle & Co., 245 Seventh Ave., New York, N. Y.

Goodrich Electro-Pak Storage Battery

Designed especially for automobile use, the battery is entirely encased in hard rubber. Cover excludes dirt, acid fumes, surface moisture, and prevents short circuits from metal dropping across the terminal. Water can be added to the cells without removing the protective cover. The case is designed with uniform wall thickness and molded hand grips. Other features include a larger condensation chamber, full-size connectors and posts, plates with rounded edges and corners, cedar separators and positive plate protectors.

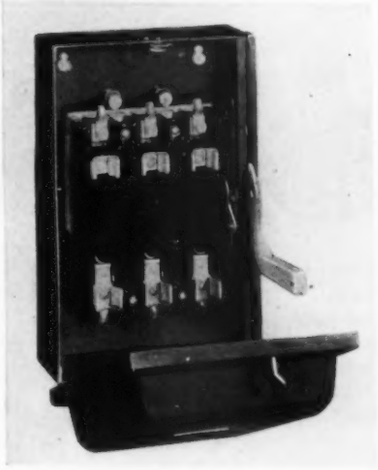
The cover is provided with four molded recesses extending part of the way through the wall from the inside at each of the corners. Recesses are broken through and filed smooth as required for the leads. The B. F. Goodrich Co., Akron, Ohio.

Roxalin Flexible Lacquer

Is a dirt-repelling wood finish developed especially to withstand severe impact service. Results of tests of this lacquer when applied to bowling pins, as reported by the manufacturer, show this lacquer to have exceptional adhesion and to be apparently chip-proof even in this severe service. Roxalin Flexible Lacquer Co., Inc., 36-40 Thirty-Sixth St., Long Island City, N. Y.

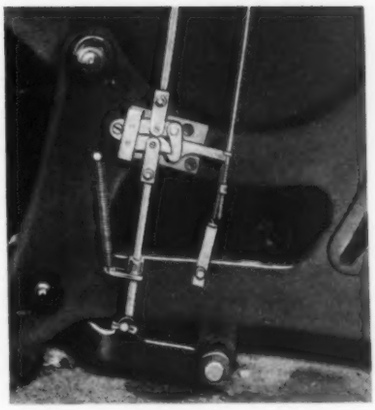
Square D Compact Switches

Smaller external dimensions are obtained by elevating the base from the back of the box by four mounting posts leaving the space to the back of the box available for wiring. To facilitate wiring the base is removable by loosening four screws. Operating handle is mounted on the side independent of the rest of the operating mechanism. The door is hinged at the bottom. Switches incorporate a door interlock, quick make and quick break, and double break contacts. Dimensions of the 3-pole, 60-amp., 575-volt switch are 13½-in. high, 8-in. wide, 5½-in. deep. Square D Co., Detroit, Mich.



Non-Repeat Device for Punch Presses

Actuated by the rotation of the press, it is said to meet compulsory requirements of state laws for a positive acting safety device. Designed for use



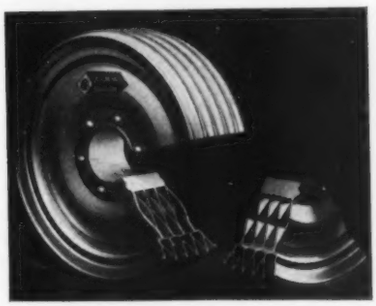
with one or two-handed controls, is inserted in the clutch rod. Arranged so that the device becomes disengaged when the crank of the press reaches the bottom of its throw, making it impossible to repeat the operation until the clutch is re-engaged after the crank reaches its top position. Working parts are of case hardened steel and bronze. Attached by three ½-in. screws. Available in two sizes, one for presses where the clutch rod is less than 8-in. long, the second size for all other types. American AllSafe Co., 71 West Huron St., Buffalo, N. Y.

Vinsol Resin

For use in insulating varnishes, impregnating compositions, lacquers, emulsion paints, and thermoplastics. Said to be a hard, black, tough, non-tacky, oil-resistant compound insoluble in drying oils and most varnish thinners, but soluble in lacquer solvents. Manufacturer states that material can be plasticized with castor oil without appreciable effect on its solubility in petroleum oils. Said to have good dielectric properties for insulation and sealing compounds. Hercules Powder Co., Inc., Wilmington, Del.

Allis-Chalmers Texsteel Sheaves

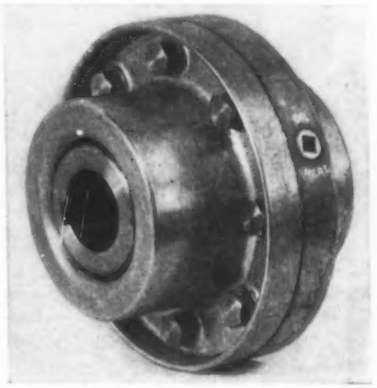
Of grid-type construction, are formed of heavy gage steel sections electrically welded at web and rim. Available in speed ratios up to 6 to 1,



using both sheaves of "Texsteel" construction. Carried in stock with 1 to 6 grooves with pitch diameters varying from 3-in. to 18-in. Are said to be well-balanced, light in weight and practically indestructible. Are supplied with an aluminum finish, with integral bushings or solid bored hubs. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Fast's Light-Duty Coupling

For shaft sizes from 1 in. to 2⅛ in. transmitting 2 to 15 hp. per 100 r.p.m. at speeds up to 3,600 r.p.m. Coupling consists of external and internal gears, permanently in mesh, encased in an oil filled casing. The hubs are of forged steel, the casings are zinc-base die-casting. Light-Duty couplings carry the same manufacturer's guarantee as the standard coupling with forged steel casing. The Bartlett Hayward Co., Baltimore, Md.

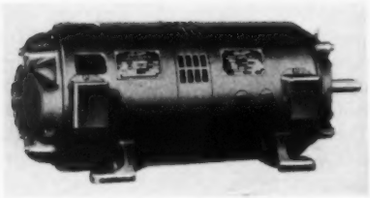


Armco Stainless Steel

In two grades, Armco 17 and Armco 18-8, is available in sheets, strips and plates. The 17 grade is for automobile parts, furnace parts, nitric acid and oil refining equipment and oil burner parts. The 18-8 grade is for airplane use, baking, laundry and dairy machinery, beer barrels, hotel, restaurant and kitchen equipment and other uses. From the experience of a number of manufacturers, the performance under dies is said to demonstrate unusual ductility and formability in these two materials. Manufacturer announces that all sizes and gages are available in stock. The American Rolling Mill Co., Middletown, Ohio.

Century Dual Motors

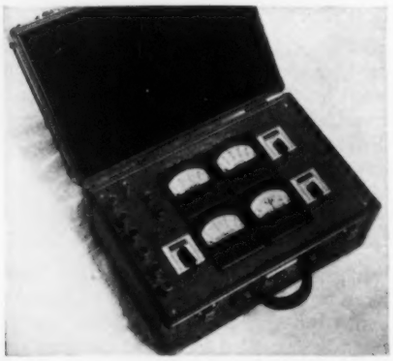
Designed to operate on either direct current or single-phase alternating current, for use where a motor device must be operated from two independent



sources of supply. Motors are semi-inclosed, rated at 1,750 r.p.m., 115 volt, d.c., or 110/220 volts, single-phase 60 cycle, a.c. Frame is of one-piece rolled steel with openings for ventilation. Removable plates in the end brackets give access to the commutator and brushes. Bearings are grease lubricated, ball bearings are supplied on the driving end and a phosphor-bronze sleeve bearing on the opposite end. Two single conductor flexible leads provide connections at a terminal box for direct current. Four leads in a terminal box at the a.c. end may be connected for either 110 or 220 volts. Direct current end is bipolar, compound wound; a.c. end is repulsion start induction run. Available in three capacities: ¾, 1, 1½ hp. Dimensions of 1-hp. size are 9⅛-in. diameter, 20-in. long. Century Electric Co., St. Louis, Mo.

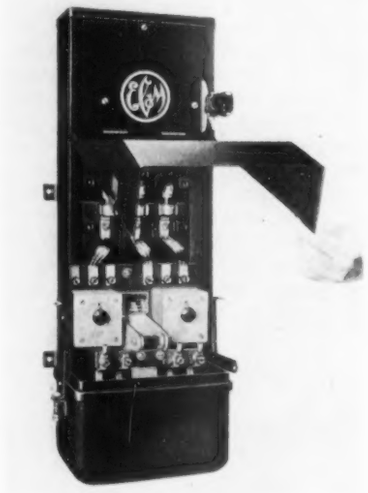
Westinghouse Industrial Analyzer

For testing household electrical appliances, industrial appliances and motors, up to 100 hp., 440 volts. A miniature portable three-phase switchboard panel is supplied with a carrying case and includes switching equipment, transformers and resistors. The four instruments are: three-range ammeter, three-range voltmeter, polyphase wattmeter with three scales and a polyphase power factor meter, all scales being 3½-in. long. Two light-weight current transformers with Hipernik cores have primary winding tapped for 5, 25 and 125 amp. Switches are supplied to connect the ammeter and voltmeter into the circuit under load. Carrying case is 7x11x19 in., with a leather handle, lock and rubber feet. Total weight is 28 lb. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



EC&M Combination Magnetic Starters

Are small and narrow for mounting in restricted spaces such as between the flanges of columns or on motor-driven machines, embody a front-operated safety switch and a vertical swinging cover. Combination magnetic starter includes an unfused or fusable safety switch, a magnetic starter with overload relays, heavy-duty test jacks. Safety switches have wiping wedge, double-break contact; magnetic starters have bushed arm bearings. Magnetic circuits said to be highly efficient and



quiet. For motors up to 15 hp., 220 volts, and 30 hp., 440-550 volts. Designated as No. 1 Type ZOS oil-immersed, across-the-line, combination magnetic starters. Electric Controller & Mfg. Co., E. 79th St. & Woodland Ave., Cleveland, Ohio.

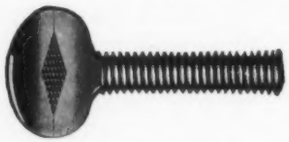
Two New General Electric Lamps

A 15-watt tubular lamp designed for use on vacuum cleaners has a double-contact bayonet candelabra base, is 2⅛-in. long. Designed to withstand bumps and high-frequency vibration, is said to provide sufficient light under ordinary room lighting conditions.

A two-filament lamp for general lighting use provides three levels of illumination from a single lamp bulb. Each of the two filaments may be burned singly or in combination. Available in two sizes: the smaller containing one 150 and one 200-watt filament, and the other with 200 and 300-watt filaments. Smaller size uses the same bulb as used in the regular 300-watt lamp, and the larger size uses a 500-watt bulb. Lamps are fitted with a mogul screw base with an additional center contact requiring a special socket that fits conventional fixtures. The lamp is inside-frosted and designed to give approximately 1,000 hours service. General Electric Co., Nela Park, Cleveland, Ohio.

Parker-Kalon Thumb Screws

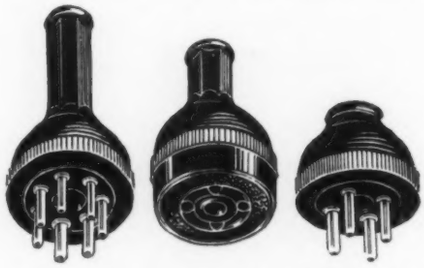
Are of one-piece construction, shaped and provided with thumb grips. Are said to be free of burrs and roughness and to take an excellent plated finish. Screws are roll-threaded. Available in a complete range of sizes from 3/16-24, ½-in. long to ⅜-16, 3-in. long. Stock finish is plain steel, but other standard finishes can be furnished if desired. Can be supplied with special



threads, special points, or made up in special metals or alloys. Parker-Kalon Corp., 200 Varick St., New York, N. Y.

Eby Rubber-Capped Plugs

For use with rubber-covered cables provides a combination said to withstand severe usage. Supplied as male or female connectors with four, five, six or seven-prong types in several styles and sizes as illustrated. Intended for service where moderate current carrying capacity is desired, and



where voltages are not in excess of 500 volts. The grade of insulating material used in the construction is said to provide extremely high resistance between conductors. Available in black only. H. H. Eby Mfg. Co., 21st St. & Hunting Park Ave., Philadelphia, Pa.

Rhamstine Photo-electric Relay

Incorporating a photo-conductive type of photocell, sensitive relay and a small battery, is designed for low-cost installation. Relay is self-contained, requiring no external current supply. Adjustment of sensitive relay is said to be easily accessible. Relay

contact capacity is 1 amp. at 110 volts, a.c.; maximum speed of operation, approximately 60 per min. Said to be suitable for control of lights, bells, doors, alarms, advertising and display signs, counting, remote measurements. J. Thos. Rhamstine, 510 East Woodbridge, Detroit, Mich.

Fiege Wire Rope Sockets

Can be attached to wire cable in the field without the use of flame or hot metal. Said to provide full cable strength. Composed of three parts: socket, sleeve and plug. Socketing is

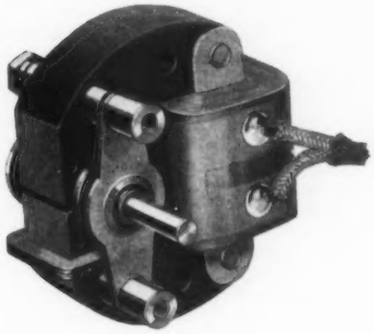
said to be completed quickly with ordinary labor. American Steel & Wire Co., Room 1404-208 S. La Salle St., Chicago, Ill.

Wire Rope Wedge Socket

For fastening rope ends in construction machinery. Designed so that wedging pressure occurs on the dead side of the rope. Machined surfaces of the groove protect rope wires from damage. Machined bearing surfaces on the wedge and in the socket are designed so that only a pre-determined amount of compression can be applied to the pulling side of the loop. This construction is said to develop more that 90 per cent of the ultimate rope strength. Available for rope sizes from $\frac{3}{8}$ to $2\frac{3}{8}$-in. diameter. John A. Roebling's Sons Co., Trenton, N. J.

Speedway Small Motors

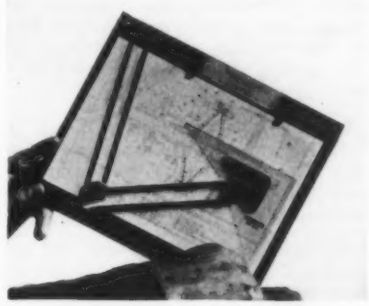
For use in fans, vending machines, display signs, small tools, toys, etc. Of skeleton construction, motors are self-contained and have self-aligning, self-lubricating bearings. Available in two designs, a shaded pole induction motor for 60-cycle a.c. single-phase



supply, and a commutator type for universal or direct current supply. Support rods are designed for ease in mounting. Shaft $\frac{5}{16}$-in. in diameter may be extended on one or both ends. Overall dimensions are $2\frac{1}{2}$x$2\frac{1}{2}$ in. with length of $2\frac{1}{2}$-in. for the d.c. type and $1\frac{1}{2}$-in. length for the a.c. type. Output as required up to 1/20 hp. SpeedWay Manufacturing Co., Cicero, Ill.

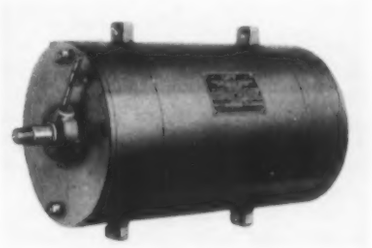
Wrigraph Draft Block

Now available in a small low-priced unit that can be carried in a brief case. Consists of a board and parallel device with a drawing attachment. Board is made of $\frac{5}{16}$-in. Masonite with paper clips for holding a single sheet or a pad of letter-size paper. Parallel device made of nickel-plated arms and wrist plates, reamed and bushed with bronze. Available with two drawing attachments, a combination of 30, 60 and 45-deg. triangle as shown with the right angle sides graduated to $\frac{1}{8}$ or $\frac{1}{10}$ in. Other attachment is a protractor with a graduated straight edge. Manufacturer states that each machine is calibrated to a master plate. Fletcher F. Milligan Company, 4638 Prospect Ave., Cleveland, Ohio.



Whitaker-Upp Generator

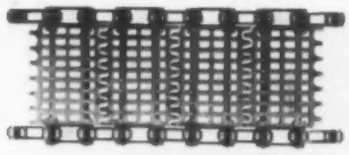
For electrically refrigerated trucks, is mounted under the hood and operates from the truck engine, supplies d.c. power at 115 volts. Consists of two rotors on the same shaft but with independent fields. Regulating generator is of the conventional third



brush type delivering current to the storage battery through a regulating winding in the power generator. Main field winding of the power generator is opposed by the regulating field winding thus decreasing the effective field as the speed increases. The generator is said to produce a constant voltage at variable speeds without the use of governors or other regulating devices. Available in three capacities; $\frac{3}{4}$, 1 and $1\frac{1}{2}$ hp., 115 volts d.c. The 1-hp. size is rated at 1,000 watts, delivers 8.7 amp., is $8\frac{1}{4}$-in. in diameter and $17\frac{1}{8}$-in. overall length, weighs 98 lb. Century Electric Co., St. Louis, Mo.

Link-Belt Conveyor for Hot Glassware

With a copper grating-type tray connected to and supported on the inner side of two strands of steel roller chain, because of the high heat conductivity of copper, is said to reduce or practically eliminate checking of hot glassware when placed on a cold con-



veyor chain. Standard width of tray is $4\frac{1}{4}$ in. with other widths available. Link-Belt Co., Indianapolis, Ind.

NEW BOOKS and PUBLICATIONS

Book of Stainless Steels

Edited by Ernest E. Thum, Editor of Metal Progress. 614 pages, 6x9 in. 289 figures. Red clothboard covers. Published by the American Society for Steel Treating, 7016 Euclid Ave., Cleveland Ohio. Price $5.

This book is comprised of contributions from 77 authorities on making and using heat and corrosion-resisting chromium alloys. Combined, they form an authoritative source for technical information on American practice in production and fabrication, as well as the properties of alloys and the requirements of the consuming industries. Careful planning and editing gives this text a logical sequence with little overlapping, yet retains the personal identity of each contributor. Coming from a number of men, each one a recognized authority in his own particular field, the information is unusually complete.

Part I covers the subject of production and fabrication, giving interesting historical data as well as detail information on steel mill and rolling mill practice, finishing and fabricating processes, welding, chromium plating and the fabrication of laminated sheets.

Part II is devoted to the properties of the typical alloys, the 5 per cent chromium steels, low and high carbon "stainless" steels, the 16-20 per cent chromium, the 25-30 per cent chromium, the 18-8 alloys and the higher alloys of chromium and chrome-nickel iron. Typical of the treatment throughout the text, the section on the 18-8 alloy is comprised of seven contributions, two from research staffs of steel manufacturers, three from steel executives, and the others from fabricators and consultants.

Part III sets forth the requirements imposed by industrial uses of stainless steel for long-time service, for chemical and food industries, for metallurgical, architectural, transportation and power uses. Along with the index in Part IV is included a classification of heat and corrosion-resisting alloys, giving the tradenames and the manufacturers.

▼

Controlled Carbon Steels

The Carnegie Steel Co., Pittsburgh, Pa., have prepared this attractive 62-page treatise on the control of quality factors in the manufacture of basic open-hearth steel. In this progress report on their study of methods for control of quality factors, emphasis is placed on the affect of steel making practices on the structure and properties of the finished product. A number of photographs and curves are given showing the effect of controlled practice on depth of hardening, toughness, hardening and physical properties and warpage. The effect of controlled steel making on cold shearing, forging, flash trimming, quenching cracks, machinability and other processing factors is shown with many interesting photographs. A bibliography of 52 references is included. The book will be of assistance to designers in specifying carbon steels for machine parts.

Aluminum—Aluminum Company of America, Pittsburgh, Pa. Booklet, 65 pages. "Alcoa Aluminum for Truck Bodies," includes operating and weight-saving data on several examples of aluminum truck bodies and aluminum foil insulation. Design information on the manufacture of aluminum truck bodies includes data on the alloys, typical body design and bills of material, and shop practices for fabrication of aluminum bodies. Information given is unusually complete and well illustrated. Booklet, 26 pages, "The Riveting of Aluminum," includes data on the strength of rivet joints, design proportions, driving procedure, and the selection of material. A companion booklet of 41 pages, "The Welding of Aluminum," covers details in procedure for flame and resistance welding.

Chromium Steels — Republic Steel Corp., Massillon, Ohio. Booklet, 12 pages, "Enduro 4-6% Chromium Steels," gives information on physical properties, creep tests, fabrication, annealing and welding.

Fiber — Spaulding Fibre Co., Inc., Tonawanda, N. Y. Booklet, 16 pages, "Reference Data on Spaulding Fibre," listing grades, properties and fabrication. Also a 4-page leaflet giving the mechanical and electrical properties on Spauldite laminated phenolic sheet.

Instruments — The Brown Instrument Co., Philadelphia, Pa. Catalog No. 6702, 80 pages, "Brown Thermometers and Pressure Gauges," with typical applications, features of construction on a new line of indicating, recording and controlling instruments and accessories.

Instruments—The Foxboro Co., Foxboro, Mass. Bulletin No. 185, 40 pages, "Pressure Instruments," includes catalog information and details of construction for recording, controlling and indicating instruments and accessories.

Lubricant — Acheson Oildag Co., Port Huron, Mich. Eight-page bulletin, "The Mechanics of Lubrication with Collidal Graphite," explains the function of graphite in lubricants.

Motors—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio. Book No. 1175, 32 pages, "Profitable Ways to Use Adjustable-Speed Motor-Drive," describes and illustrates applications of various types of d.c. and a.c. adjustable speed motors.

Optical Instruments — Bausch & Lomb Optical Co., Rochester, N. Y. Booklet, 46 pages, "Optical Instruments for the Metal Working Industries," a well illustrated catalog giving prices, specifications and uses of projectors, microscopes and magnifiers for shop and laboratory.

Photo-Electric Cells—Weston Electrical Instrument Corp., Newark, N. J. Circular, 22 pages, "Technical Data—Weston Photronic Cell," giving definition of terms used in connection with light measurements and the peformance and operating characteristics of the photocell, including ten charts covering factors involved in application of this dry-disk cell.

Plastics — General Plastics, Inc., North Tonawanda, N. Y. Booklet, 8 pages, "The Durez Primer," illustrates seven applications for synthetic plastics.

Screws, Bolts, Nuts — Pheoll Mfg. Co., 5700 Roosevelt Road, Chicago, Ill. Catalog No. 34, 104 pages, giving price lists and illustrations of standard and special screws, bolts and nuts in carbon, nickel, chromium and stainless steels; copper, brass, bronze, nickel silver, aluminum and monel metal. Included is a section of 30 pages of reference tables of interest to the designer.

Stainless Steel—The Carpenter Steel Co., Reading, Pa. Booklet, 20 pages, "Working Data and Technical Facts on Carpenter Stainless Steel." Physical properties, heat-treatment and working of nine types, and a chart giving a summary of technical data.

Stainless Steels—National Tube Co., Pittsburgh, Pa. Booklet, 40 pages. "National Stainless and Heat-Resisting Pipe and Tubes," includes information on fabricating practice, uses and applications, resistance to chemicals and properties of the alloys. Well illustrated and complete.

Steel—Peter A. Frasse & Co., Inc., Grand St. at Sixth Ave., New York, N. Y. Stock list, 108 pages, including some data on a complete line of steel and alloy steel bars, tubes, strips, sheets.

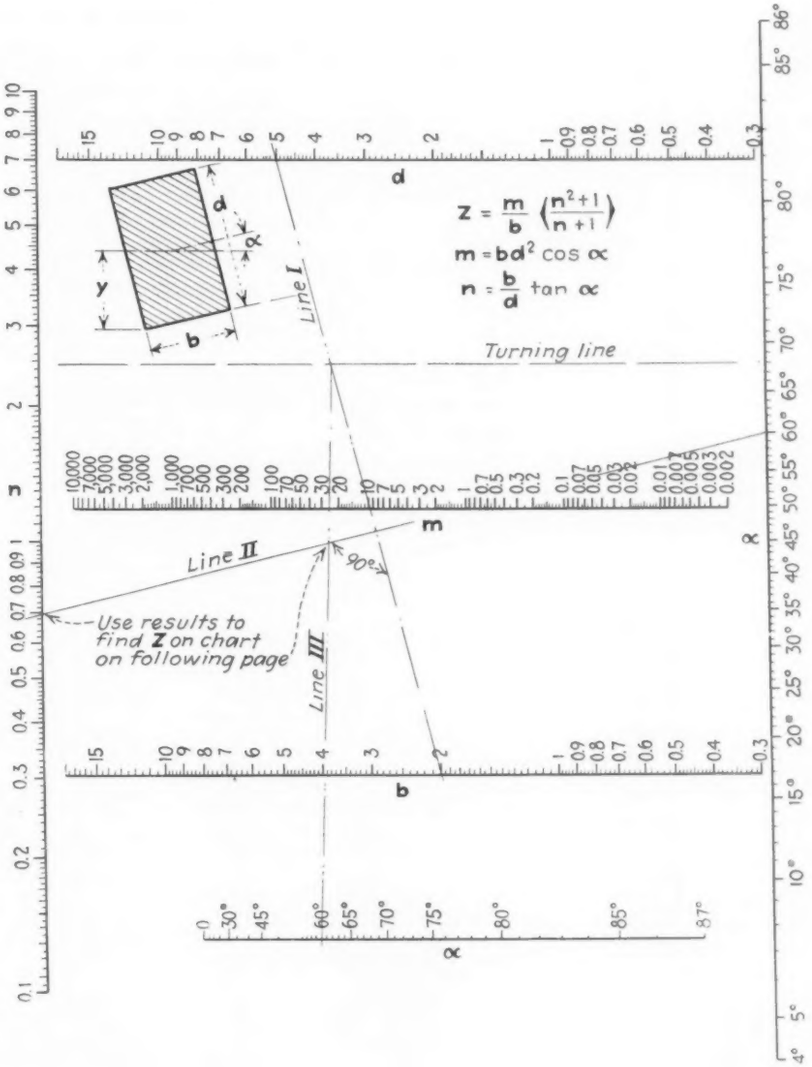
Stop Nuts — Elastic Stop Division, A.G.A. Co., Elizabeth, N. J. Data book, 12 pages, "Technical Data on the uses of Elastic Stop Nuts," giving typical applications in aeronautic, automotive, electrical industries. Use and limitations, design data, and catalog information also included.

Zinc Products—New Jersey Zinc Co., 160 Front St., New York, N. Y. Reprint, 18 pages, "Case Histories in Product Design," includes the series of six articles that appeared during 1933 in *Product Engineering* covering the development of 18 successful products. For each of the products described is given the name of the manufacturer, the engineering designers, the art designer, and the sales results attained.

Modulus of Section at Angle α

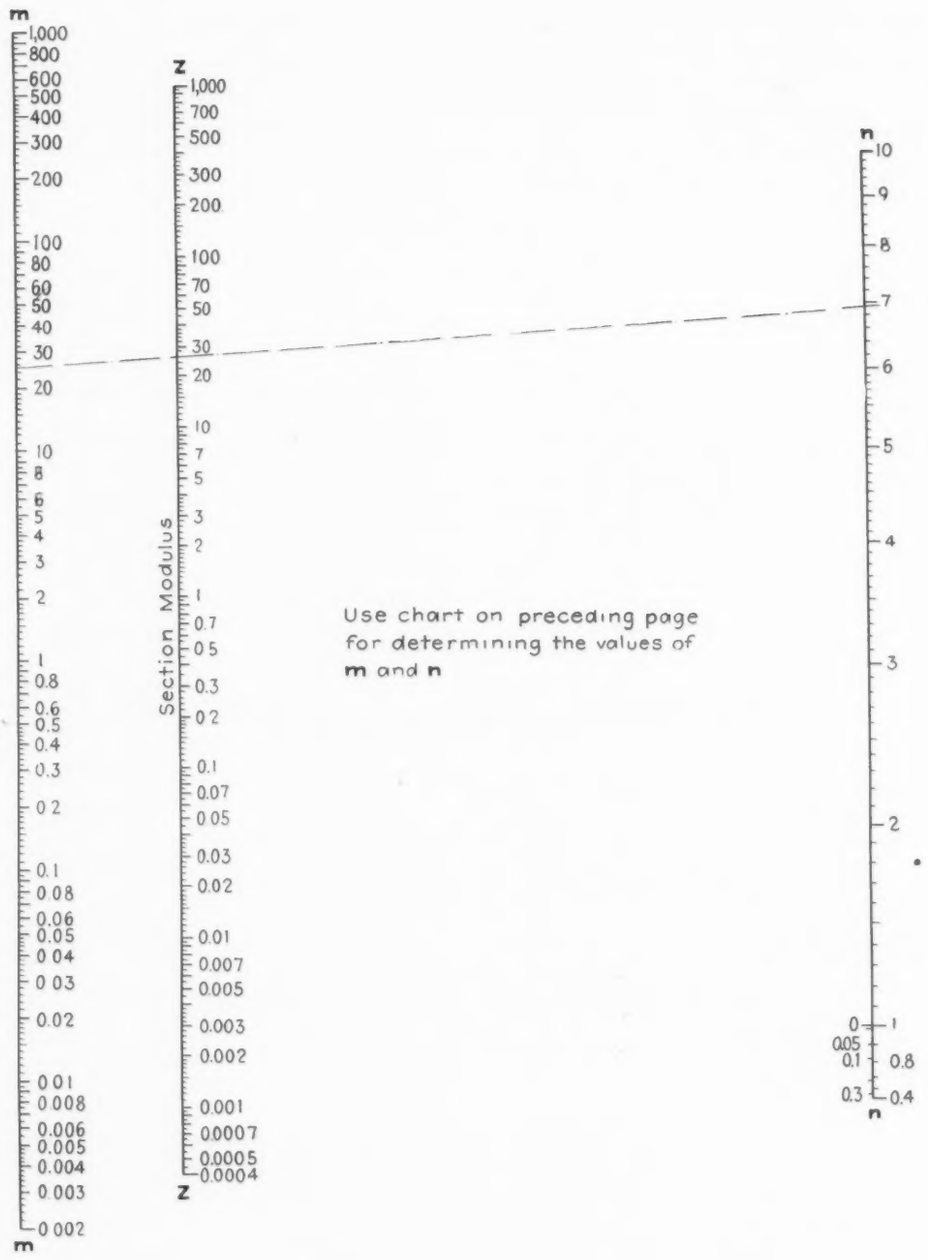
M. G. Van Voorhis

DRAW *Line I* and *Line II* perpendicular to each other on a transparent sheet of paper which is placed over the chart, making *Line I* intersect the *b* and *d* scales and *Line II* intersect the α scale to the right at the given values. The value of *n* is given in the left-hand scale. Join the intersection of *Line I* and the *Turning Line* with the value of α on the lower scale, the intersection of this *Line III* with the *m* scale giving the value of *m*. With these values of *m* and *n*, the modulus of the section at the angle α is found as indicated on the chart on the page following.



PRODUCT ENGINEERING © REFERENCE BOOK SHEET

Modulus of Section at Angle α



PRODUCT ENGINEERING © REFERENCE BOOK SHEET

PRODUCT ENGINEERING

CONTENTS • DECEMBER • 1933

Copyright 1933 by McGraw-Hill Publishing Company, Inc.

VOLUME 4 . . . NUMBER 12

Hydraulic Versus Mechanical Feed—I 442
A. L. DeLeeuw

Product Developments 446
Items That Indicate Trends

The Scope of Photo-Elastic Analysis 450
A. G. Solakian

Initial Wear 452
R. E. W. Harrison

Spring Wire Locks and Snap Rings for Fastenings 454
Adam Fredericks

Types of Plastics and Their Properties 456
H. M. Richardson

Properties of Phenolic Laminated Materials 460
Classified According to the N.E.M.A.

Fine Appearance Without Complications 462
An Interview with Walter Dorwin Teague

Color Response of Photocells 465
R. C. Hitchcock

Modulus of Section at Angle α 479
M. G. Van Voorhis

Editorials..... 441 Communication and Comment..... 468 News..... 472
Meetings and Exhibitions..... 473 New Materials and Parts..... 474

Index for Vol. 4 Follows the Advertising Pages

IN THIS ISSUE

Mechanical Design—There is always the temptation to adopt the new without a proper consideration of its merits relative to the old. The lead article of this number gives an unbiased comparison of the merits and shortcomings of hydraulic versus mechanical feed. We know it is unbiased because it was written specially for *Product Engineering* by A. L. DeLeeuw who as early as 1892 designed hydraulic operated machine tools, and since then has designed machines with both mechanical and hydraulic feeds.

The life of most machines is determined by wear, and the initial wear is the greater. R. E. W. Harrison, also a consulting engineer, forcibly brings home the relation between initial wear and surface finish.

Photocells—An exposition of the relative response of the various types of photocells to different colors.

Materials—A comprehensive article setting forth the different types of phenolic plastics, the fillers and binders used and two tables giving all the important properties.

COMING ISSUE

Next month we conclude the article on hydraulic versus mechanical feeds. In another article H. M. Richardson will show typical calculations for the design of machine elements made from phenolic laminated materials.

With the January number we also fittingly begin a second series of "Case Histories" prepared for *Product Engineering* by T. J. Maloney, well known to our readers as the co-author of the series that appeared during this past year.

Looking ahead further, we will also have two comprehensive articles on "Worm Gear Efficiency" by C. H. Grill, formerly chief engineer of the Philadelphia Gear Works.

KENNETH H. CONDIT
Editor and Publishing Director

GEORGE F. NORDENHOLT, *Associate Editor* · R. W. CARSON, *Assistant Editor* · LEONARD CHURCH, *Cleveland* · PAUL WOOTON, *Washington*

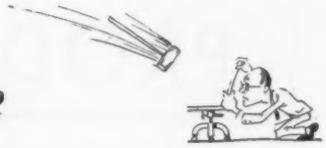
Published monthly. Price 25c. a copy. Subscription rates—United States, Mexico and Central and South American countries, $2.00 a year. Canada, including duty, $2.50 a year. All other countries $4.00 a year or 16 shillings. Entered as second-class matter January 17, 1930, at Post Office at New York, N. Y., under the Act of March 3rd, 1879. Printed in U. S. A. Cable address "McGrawhill, New York." Member of A. B. P. Member of A. B. C.

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42d STREET, NEW YORK, N. Y.

Branch offices: 520 North Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, Aldwych, London, W. C. 2; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Greenville, S. C. James H. McGraw, Chairman of the Board; Malcolm Muir, President; James H. McGraw, Jr., Vice-President and Treasurer; Mason Britton, Vice-President; Edgar Kobak, Vice-President; H. C. Parmelee, Vice-President; Harold W. McGraw, Vice-President; B. R. Putnam, Secretary.

Printed by The Schweinler Press, N. Y.

Intimate Correspondence



Good Reflexes

PRODUCT ENGINEERING
NEW YORK

We have just received our first copy of *Product Engineering* and, in looking over this, we find that there are two criticisms which we would like to make.

The first refers to page 440 which is a data sheet, giving the minimum pitch diameter of spur gears by the chart method. It so happens that we had occasion to use this chart almost immediately after the receipt of this copy and found, much to our disappointment, that it only ran down to 6 D.P. The gear in question was a 10-pitch gear: therefore, we could not use this chart for the particular purpose in mind. We are wondering if it would be possible for you to extend this down further and print such a chart in one of the following issues.

The other criticism is in regard to closures as suggested by Mr. Wasbauer. Of the several closures which he shows on these sheets, I particularly notice that he has not used the new style oil seals, such as are manufactured by Gits and other concerns. In the past we have found this type of seal very efficient and feel that probably this has been overlooked.

We trust that these criticisms will be received in the spirit in which they are given.

L. P. MARTIN,
Chief Engineer,
Johnson Gear & Mfg. Co., Ltd.

MR. MARTIN'S reflexes are evidently in excellent condition. He found two things he didn't like in his first copy of *Product Engineering,* and immediately told us about them. If only more readers of the paper would be equally quick to let us know when one of our omissions or commissions disappoints, how much easier our job would be.

As for the chart the scale of circular pitch extends down to zero. As 10 diametral pitch is 0.3141 circular pitch. the required point can be located. The diametral pitch scale was arbitrarily stopped at 6 to avoid crowding. The bearing seals are ones used by Mr. Wasbauer in his own practice. Omission of the other types is no reflection on their merit.

Product Engineers

PRODUCT ENGINEERING
NEW YORK

We have been taking *Product Engineering* regularly for some little time and we find it interesting and helpful.

Do you know of any association of product engineers or any such group that work together in the problem of new products?

RALPH L. DREW,
Specialty Department,
Plymouth Cordage Co.

AS YET there is no society or association of product engineers, so far as we know. A machine design committee has staged several meetings, under A.S.M.E. sponsorship, and the industrial artists have occasional luncheon meetings in New York. To fill this gap we are trying to make *Product Engineering* serve as the medium for discussion of the sort of problems product engineers talk about. We believe we have had some success in this attempt but we are more than willing to follow suggestions that will improve the service.

Equations

PRODUCT ENGINEERING
NEW YORK

The otherwise excellent article beginning at page 372 of the October *Product Engineering* is marred by what may not be errors, but which appear to be either the writers or editorial indiscretions.

Middle of same column. Would it not be better to print instead of 1/2 the ordinary fraction ½? For 1/2 $(D_A + D_B)$ can easily be read to mean, as I naturally read it before noticing what so doing would imply,

$$\frac{1}{2\,(D_A + D_B)}$$

instead of

$$\frac{D_A + D_B}{2}$$

Personally I would have written the expression thus:—

$$(D_A + D_B)/2$$

FRANCIS W. SHAW,
Shaw & Son.

MR. SHAW raises an important question. May we ask readers for their opinion on the way we have been handling equations? They are difficult things typographically but we will try to improve our treatment if necessary.

PRODUCT ENGINEERING
NEW YORK

In the January 1930 issue of *Product Engineering* pages 49 and 50 (reference book sheet) there appeared some helpful charts in capacity and deflection of helical springs.

It would be appreciated if you would forward six (6) copies of this reference sheet to the writer. The cost of the sheets, plus mailing expense, will be remitted upon their receipt.

ACME STEEL COMPANY,
Wm. Page,
Engineering Department.

MR. PAGE'S request is just one more indication of the value of the reference material to be found in every number of *Product Engineering.* Unfortunately it is seldom possible to take care of such requests except by making photostatic copies of the pages wanted. We reserve a limited number of copies for clipping purposes but they seldom hold out for more than a year. We earnestly request those who make a practice of filing *Product Engineering* pages to be sure that they have enough subscriptions to take care of the "clippers." Just recently we found a chief engineer whose files were incomplete because two of his associates also had the clipping habit, and there was only one copy for the three of them to clip. One clipping available at the right moment may well be worth many times the cost of an extra subscription.

Further Information

PRODUCT ENGINEERING
NEW YORK

On page 353 of the September 1933 issue of *Product Engineering* is made a reference to a "corrosion-resistant cast iron," developed in England.

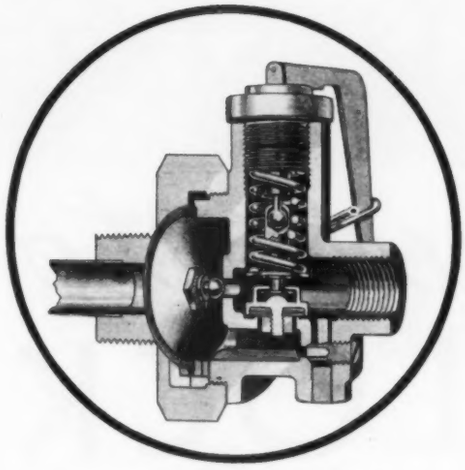
Is it possible for you to tell us who has developed this material, so we may get in touch with them?

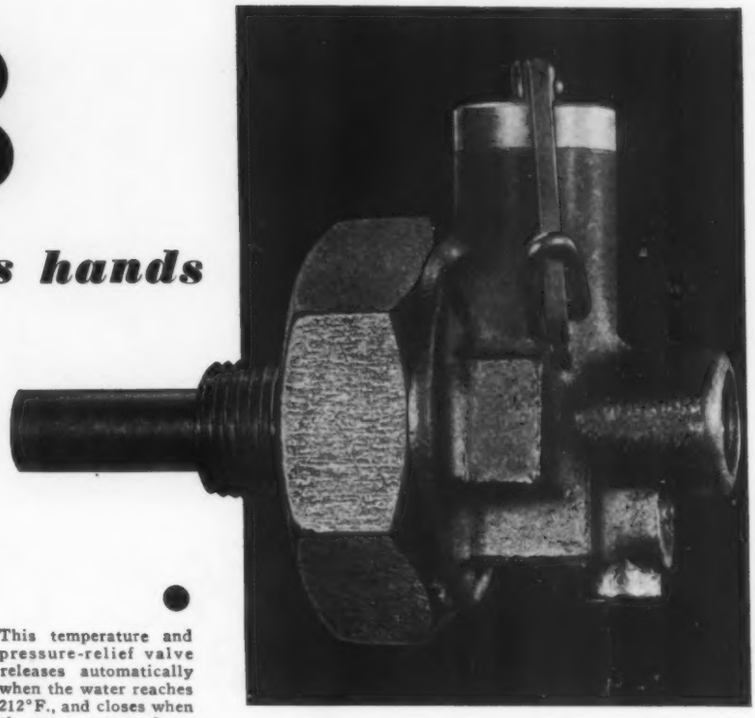
Frequently it is desired to obtain further information regarding references made in this valued periodical. Possibly you can advise us as to whom to contact in your organization.

J. M. SAMPSON,
Works Laboratory,
General Electric Company.

FOR the benefit of others in the same fix as Mr. Sampson we want to say that a letter, wire or phone call to the editor will bring all the further information we are able to get. If we haven't it at the moment we have plenty of resources to fall back upon. The editors of more than a score of McGraw-Hill papers are within call and we have correspondents all over the world. Use them.

We take a TOUGH JOB off our customer's hands





This temperature and pressure-relief valve releases automatically when the water reaches 212°F., and closes when the temperature drops below. (An emergency fusible plug is an additional guard against high temperatures.) Protection against over-pressure is provided by a spring-loaded valve. It opens when the pressure exceeds a pre-determined amount, and closes again as soon as the excess pressure is relieved. Operation is positive, efficient, trouble-free.

LOOK at this ingenious valve for hot-water boilers. . . . We make it, test it, and ship it complete—all ready for delivery to the plumber. The job involves two castings, several screw-machine parts, a stamping, a wire-formed part, a special loading-spring. And a series of very accurate machining, assembling, and testing operations. (A thermostatic disc is furnished by the customer.)

We specialize in this "made-to-order" manufacturing. We have the facilities and skill to handle it right. And the customer for whom we do the job is left free to devote his *entire time* to selling and distribution. . . . No production worries for him!

Do you have any jobs involving the manufacture of metal parts or metal products? Let a specialist take the work off your hands . . . relieve you of extra burdens, extra overhead. We are equipped to serve you efficiently, economically—as we have served thousands of companies in every industry.

Executives, plant superintendents, engineers, purchasing agents—write for our interesting free folder, "Cases and Conclusions." Address Scovill Manufacturing Company, 35 Mill St., Waterbury, Connecticut. No obligation.

Scovill

SCOVILL

SCOVILL MANUFACTURING COMPANY, WATERBURY, CONNECTICUT

New York *Syracuse* *Philadelphia* *Boston* *Providence* *Chicago* *Detroit*
Cincinnati *Atlanta* *San Francisco* *Los Angeles* In Europe: *The Hague, Holland*

Only

GARLOCK PACKINGS

are built to GARLOCK *standards*

THOUSANDS of Purchasing Agents and Engineers in all parts of the world have learned that it is economy to standardize on Garlock materials. Those men are accustomed to receiving maximum packing service at minimum packing costs. They specify "Garlock" on every packing requisition and accept no substitute for Garlock quality.

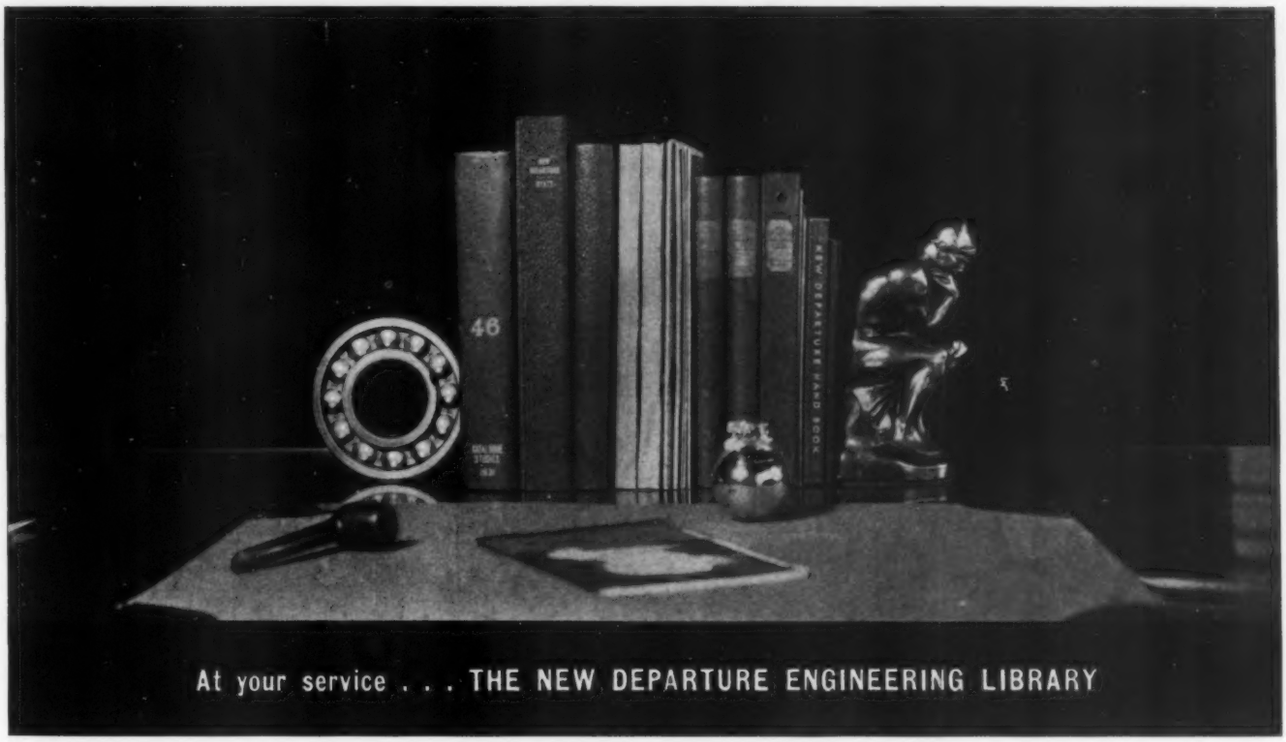
To keep faith with those men by maintaining the traditional Garlock quality standards is the first consideration of the Garlock organization of packing specialists with its background of almost fifty years devoted exclusively to the study, development, manufacture and distribution of mechanical packing materials.

A Garlock representative is at your service.

THE GARLOCK PACKING COMPANY, Palmyra, New York

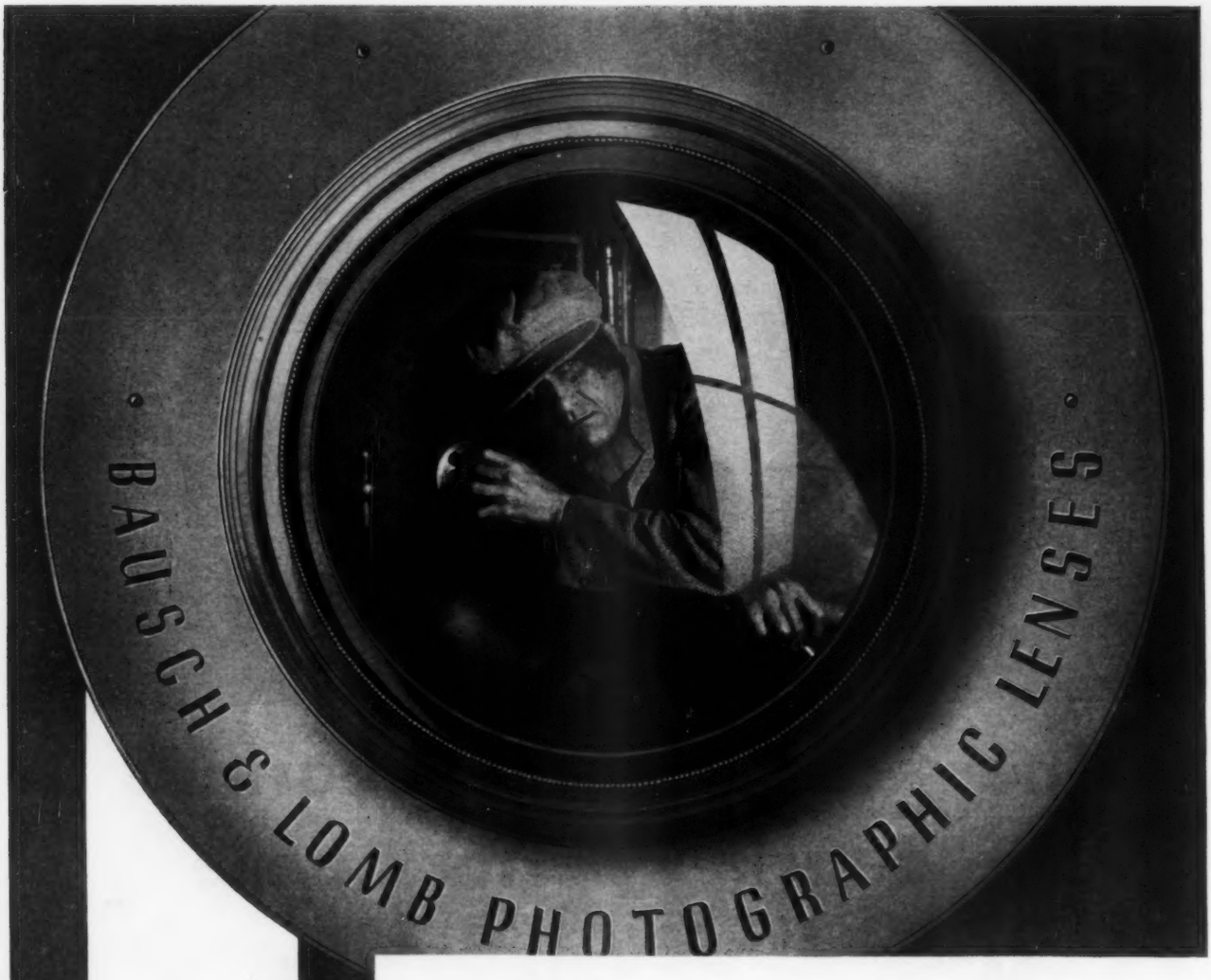
In Canada: The Garlock Packing Co. of Canada, Ltd., Montreal, Que.

GARLOCK *Quality Controlled*



There's more than bearings to bearing performance

MANUFACTURERS are depending more and more on New Departure's engineering experience and ingenuity for economical manufacture and assured performance. » » » New Departure has never been satisfied just to make a bearing — and let it go at that. » » » New Departure's product is ideas as well as bearings — and its ideas have pioneered new bearing practice since the industry began. » » » And New Departure will continue to research and originate for the benefit of the industry. The results are always available upon request. The New Departure Mfg. Co., Bristol, Connecticut; Detroit, Chicago, San Francisco and London, England.



What next? Now They're Photographing Burglars at Work

THE Bausch & Lomb Scientific Bureau offers you assistance in the adaptation of lenses, prisms, reflectors or complete optical units to your specific problem.

The following are typical:

The Oshkosh Photo Identification System—a new hidden silent camera with Bausch & Lomb lenses that automatically makes a series of pictures of robberies and hold-ups.

The Folmer-Graflex new *National GRAFLEX Camera* is equipped with a specially designed Bausch & Lomb lens.

Remington-Rand's new *Dexigraph* is equipped with Bausch & Lomb special photographic lenses to make more than 2,000 photographic copies of business papers per hour in actual size or reduction.

The Eastman Hi-Speed Camera with Western Electric Timing System —takes 2,000 exposures per second for motion analysis, with a special Bausch & Lomb lens.

Without obligation, write us concerning any engineering problem involving optics.

Bausch & Lomb Optical Company

601 ST. PAUL STREET • • • ROCHESTER, NEW YORK

Mail Today

The coupon will bring you a prompt reply to your specific optical problem.

Mail coupon now, or tear out as a reminder to write.

Bausch & Lomb Optical Co.,
601 St. Paul St., Rochester, N. Y.

Gentlemen:—I want information on_____

_____

Name _____

Firm _____

Address _____

IT'S OFF — IT'S ON — *with* BULLET SPEED

NO ARCING - NO WEAR

with this thermostat

WHEN thermostat contacts make and break the electrical circuit of your heating appliance with the speed of a rifle bullet . . . you can be sure that your product is under reliable control.

The bullet-speed action of the Westinghouse Built-in Watchman Thermostat eliminates arcing and the resultant pitting of its contacts. Half a million test operations without a single failure have proved the dependibility of this little disc thermostat.

Faster heating, maintained temperature and positive protection of your product from overheating and burn-outs are advantages that the Built-in Watchman can give your product . . . to help your salesmen sell.

Send coupon today for complete information that will guide you in making the most of this outstanding selling feature.

Westinghouse

Quality workmanship gvarantees every Westinghouse product

The Westinghouse Built-in Watchman Thermostat is a simple, trouble-free, and inexpensive heat-control device.

4 SALES *Advantages*

1 *Faster heating*
2 *Maintained temperature*
3 *Positive protection*
4 *Trouble-free performance*

SEND FOR INFORMATION

Westinghouse Electric & Manufacturing Company
Industrial Heating Division, Mansfield, Ohio.

Gentlemen: Send me complete information on the Built-in Watchman.

Name .....

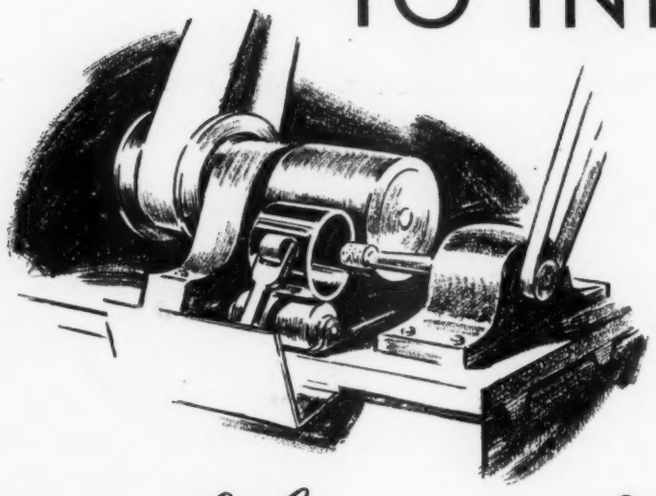
Address .....

Product .....T 79640

Approximate yearly requirements .....PE 12-33

Note: Be sure to name your product. Due to a few exclusive arrangements this device cannot be sold for all applications.

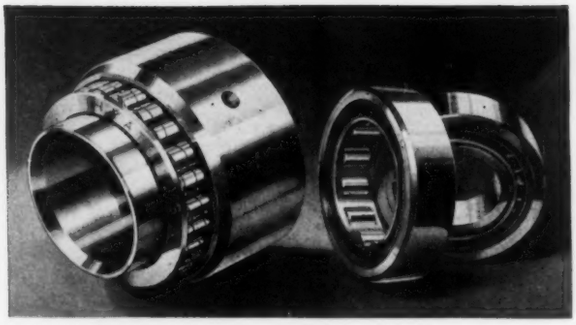
WE HAND A NEW TOOL TO INDUSTRY



Chuckless grinding

The problem of making races for bearings with wall variations held to an irreducible minimum, that is, with bores and outside diameters truly concentric, has intrigued engineers for years.

Hyatt determined to solve the problem and now with considerable pride and satisfaction we announce the new process which we have originated and nurtured through persistent effort—we call it chuckless grinding.



Soon, all other industries may benefit from this Hyatt research and experimentation which has taken years of effort and which to perfect, cost thousands of dollars in our plant and elsewhere.

But, the furthering of this revolutionary development of grinding accuracy in race manufacture, is only another measure of Hyatt endeavor to find better ways to safeguard quality. We thus hope to insure the continued faith of Hyatt customers. Hyatt Roller Bearing Company, Newark, Detroit, Chicago, Pittsburgh, Oakland.

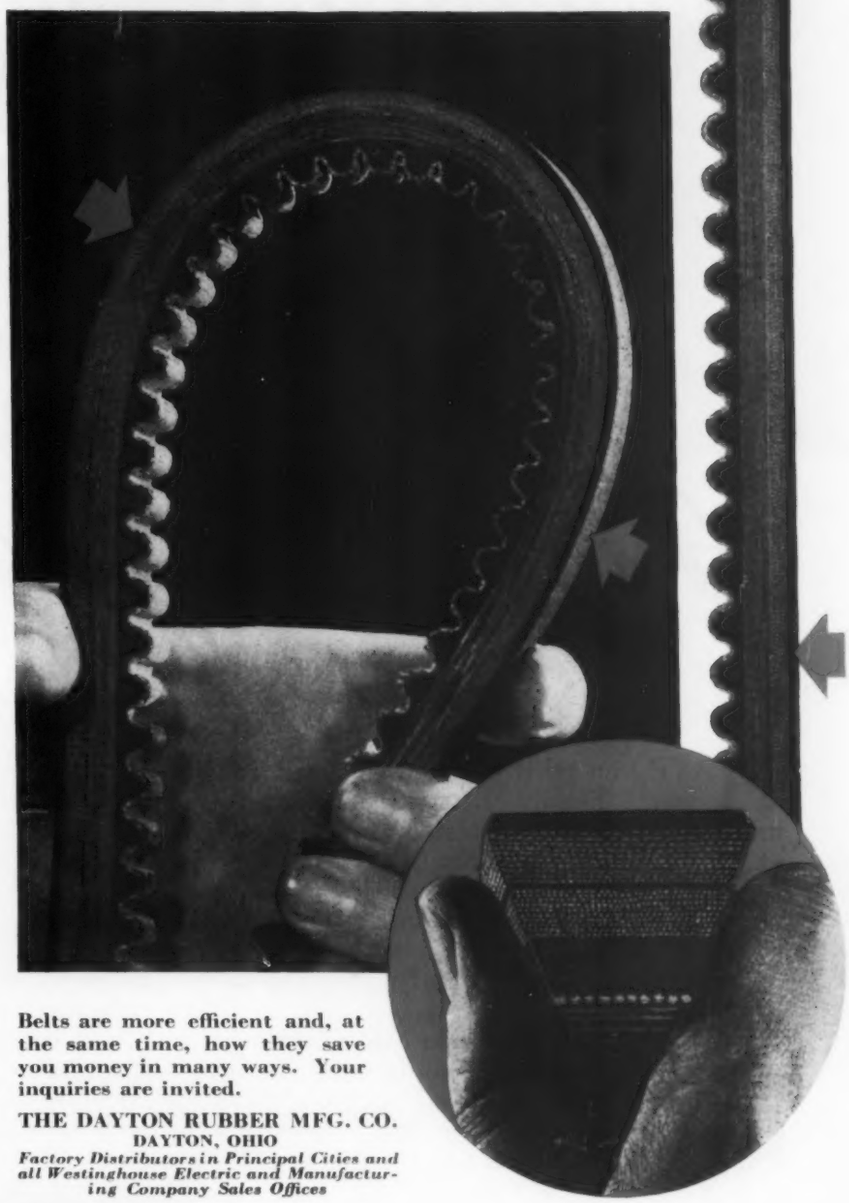
H Y A T T

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

MAKE THESE TESTS

Compare the Dayton Cog-Belt with any other V-Belt in vital principles of construction



First, mark two points four or five inches apart on the outer surface of a belt. Then bend the belt *double*. And while doubled, measure the distance between the marks again. Note how far the outer section of the belt has stretched. This shows how the outer section of any belt must stretch when going around a pulley.

The Dayton Cog-Belt is the only V-Belt built to take this "stretch" without strain or distortion. The outer section is made of bias-cut fabric—it "gives" without strain; like pulling your handkerchief from diagonally opposite corners.

Also, while the belt is flexed, note how the cogged inner surface has compressed—how the cogs have closed and "taken-up" the compression on the inner surface of the belt.

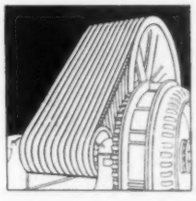
Second, compress a section of a Dayton Cog-Belt between the thumb and forefinger and note the extreme crosswise rigidity. Because of this positive crosswise rigidity there can be no "squashing" in the pulley groove . . . no distortion or twisting.

No other V-Belt combines such extreme flexibility with such positive crosswise rigidity.

And because Dayton Cog-Belts offer these exclusive advantages—because they are *built to bend*—because they have such positive crosswise rigidity—they provide maximum contact arc, have greater gripping power, permit smaller pulleys with closer centers, save floor space, run cooler, require less tension, are easier on bearings, last longer.

But don't stop with making these tests. Let us give you more of the facts—facts that prove how Dayton Cog-Belts are more efficient and, at the same time, how they save you money in many ways. Your inquiries are invited.

THE DAYTON RUBBER MFG. CO.
DAYTON, OHIO
Factory Distributors in Principal Cities and all Westinghouse Electric and Manufacturing Company Sales Offices



Dayton
COG·BELT DRIVES

We made it easier to MACHINE... *to* GRIND... *to* POLISH...

YET WE HAVE KEPT ITS CORROSION RESISTANCE AND UNIFORMITY

And here's proof!

HAVE you tried to machine 18-8 stainless? Then you know what a statement this is—"The material is run through at 80% of the speed regularly used . . . the drill was in perfect condition after 15 hours." And you can understand this comment—"It machines about half-way between ordinary 18-8 and screw stock."

Both these remarks refer to Carpenter Stainless Steel No. 8, the free-machining 18-8 stainless steel. These and dozens of similar stories offer you proof that it's EASIER TO MACHINE.

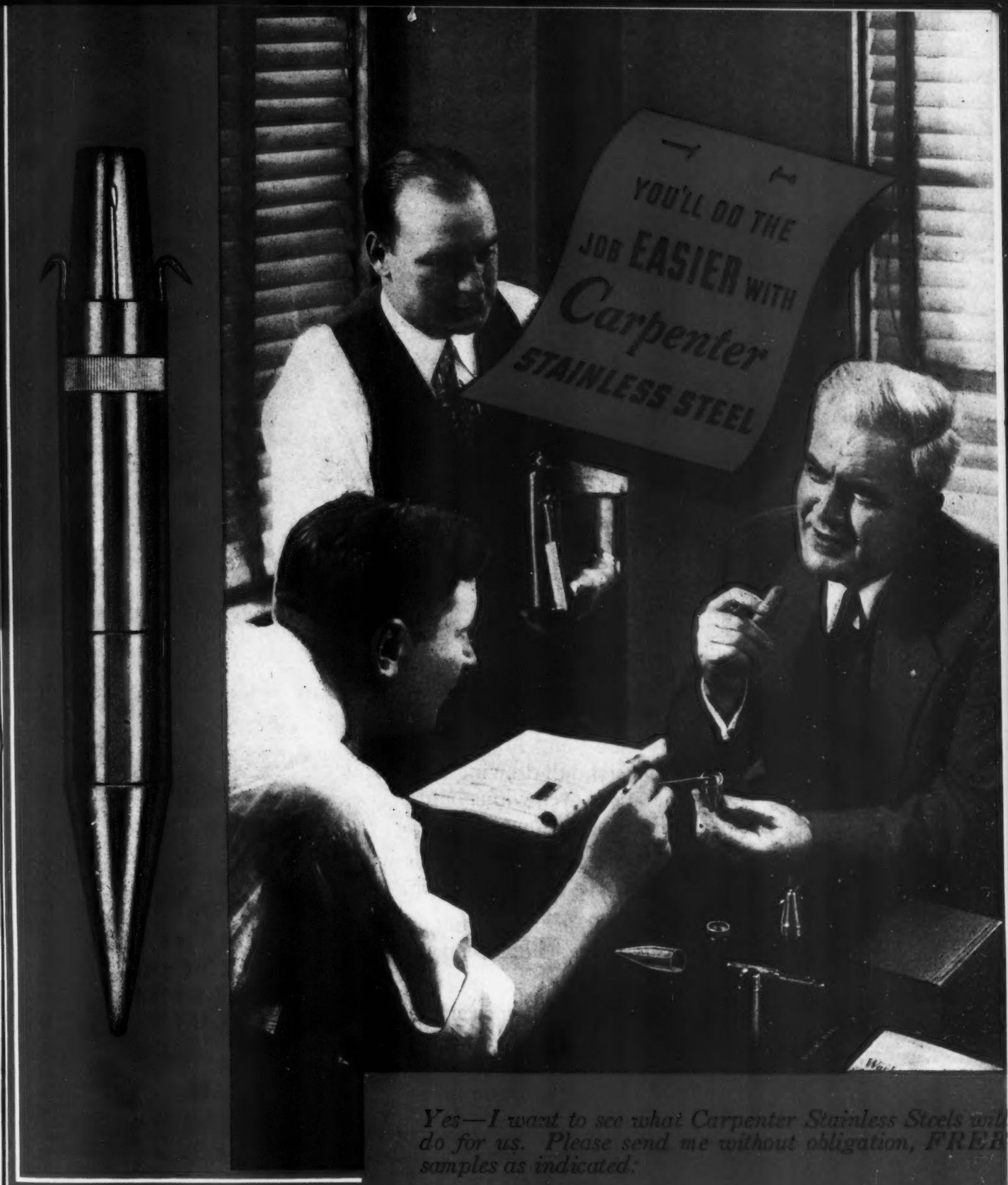
And difficulty of grinding once kept stainless out of many uses where it was needed. But Carpenter makes a stainless which has "8 times the grindability of ordinary 18-8 stainless" according to no less an authority than the Carborundum Company.

For stampings or moldings, a single buffing operation gives an everlasting brilliance to many objects made of Carpenter Stainless Strip Steel—making stainless steels more economical in many cases than plated substitutes.

In these three cases and in many others our customers tell us that Carpenter Stainless Steels are ahead of the field. Yet you may want more proof. We'll be glad to send you samples that you can try on your own presses or screw machines . . . in your own plant . . . on your own products—so you can see for yourself that Carpenter Stainless Steels will help you do the job EASIER.

Whether your interest is in Stainless bar steel or cold rolled strip, return the coupon today. Get your free samples and try them in your own machines right away.

Carpenter STAINLESS



Yes—I want to see what Carpenter Stainless Steels will do for us. Please send me without obligation, FREE samples as indicated:

WHAT OPERATION DO YOU WANT TO TEST? _____

WHAT SIZE? _____

(To insure prompt shipment, give us as much leeway as possible)

NAME _____ TITLE _____

FIRM _____

STREET and NUMBER _____

THE CARPENTER STEEL COMPANY
117 West Bern Street : Reading, Pa.

Licensees of American Stainless Steel Co, and of Chemical Foundation, Inc.

Try it!

■ Made with the same uniform reliable base cloth as used in IMPERIAL tracing cloth.

But has a special dull drawing surface on which lines made even with a hard pencil, appear sharp and opaque.

As suitable for ink work as the well-known IMPERIAL tracing cloth.

Pencil lines will not smudge, but erasures can be easily made without damaging its surface.

Because of its high transparency and its excellent ink and pencil taking qualities, sharp contrasting blue prints can be produced from tracings made on it.

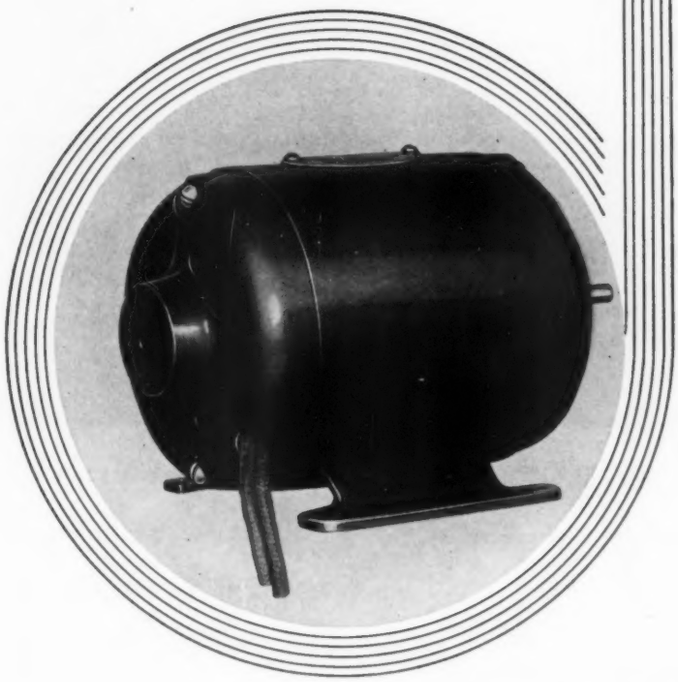
A PRODUCT OF THE MANUFACTURERS OF THE WORLD RENOWNED IMPERIAL TRACING CLOTH

IMPERIAL PENCIL TRACING CLOTH

REG. U.S. PAT. OFF.

for Sale by
LEADING Stationery and Drawing Material Dealers ◆ ◆ EVERYWHERE

Two NEW G-E MOTORS for Motorized Products which should interest you



Because . . .

Modern and dependable — the new line of G-E series and shaded-pole motors combines light-weight rolled-shell construction with adequately lubricated oil-return bearings. An improved ventilating system means more power without increased weight. These motors can be easily adapted to your special requirements, with little or no departure from standard design. Longer service life and high standards of performance provide long, care-free service to the user of your motorized products.

Many other details of these new motors are of vital interest to you.

NRA MEMBER U.S. WE DO OUR PART

GENERAL ELECTRIC

The complete G-E line of fractional-horsepower motors includes all types for a-c. and d-c. service, in standard frequencies and voltages, and in a wide variety of ratings. All are dependable, electrically correct, highly efficient, adaptable. A fractional-horsepower-motor specialist in the nearest G-E office will be glad to work with you in solving your motor problems.

MAIL FOR COMPLETE DETAILS

Address the nearest G-E office, or General Electric, Dept. 6B-201 Schenectady, N. Y.

Please send me your bulletin describing and illustrating the new:

( ) Series motors (GEA-1277A)
( ) Shaded-pole motors (GEA-1844)

NAME.....

COMPANY.....

ADDRESS.....

210-225

TOUGH *by any test*

● If toughness after heat treatment is a vital requirement in your steel, then Carnegie Controlled Carbon Steels warrant your investigation. Through positive control of quality factors in their manufacture, the scope of these steels in all carbon ranges now includes many uses heretofore requiring higher priced alloys. One user reports that he has not only reduced his steel costs but in addition has cut his processing costs 11%.

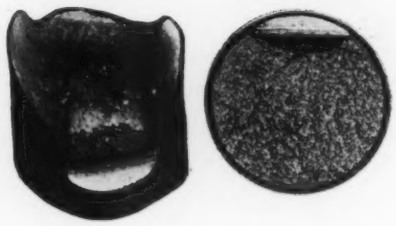
Let our metallurgists help you to determine the grade and character of steel best suited to your purpose. Once this has been developed, you may be sure that every succeeding heat will respond to your process in an equally satisfactory manner. This is accomplished through scientific control of metallurgical practice, including control of austenitic grain size heretofore believed by many as impossible in basic open hearth steels.

The booklet "Carnegie Controlled Carbon Steels" will be sent you upon request.

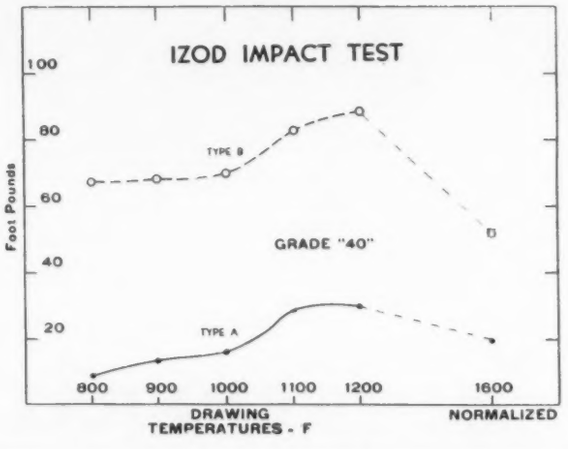
DISTORTION TEST

TYPE B TYPE A

These tests compare two .40 carbon steels of same analysis and identical treatments.



FRACTURE TEST



ENDURANCE LIMIT—R. R. Moore machine in air,
Grade .50 Type A 66,500 pounds per square inch
Type B 71,000 pounds per square inch

CARNEGIE STEEL COMPANY • PITTSBURGH

240 Subsidiary of United States Steel Corporation

CARNEGIE
Controlled
CARBON STEELS

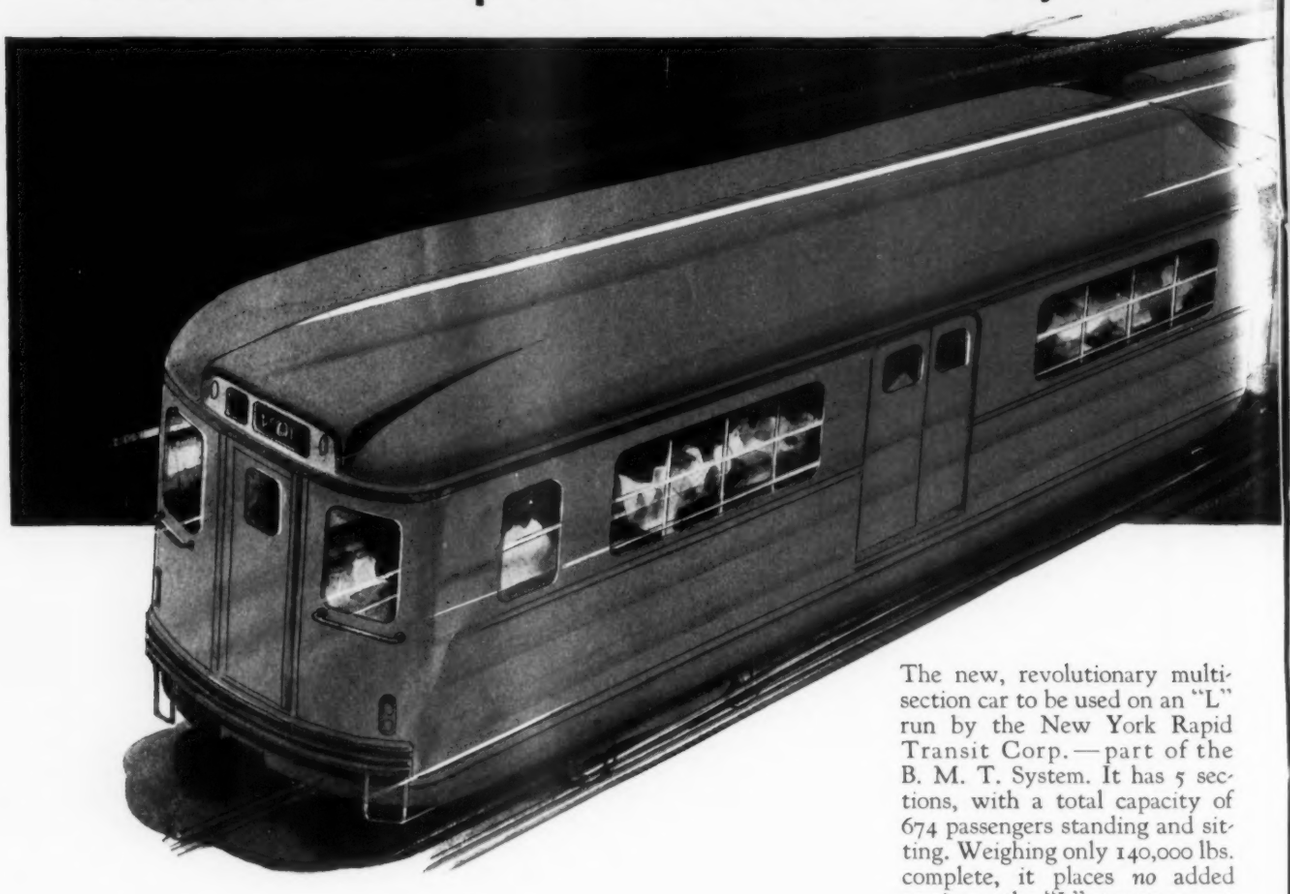
• *Unexcelled in strength by any other molding composition. Bends without breaking. In all colors and degrees of transparency. Lustrous, smooth, pleasant to the touch. Slow burning, non-hazardous. Uniform in texture, holds to close tolerances in molding and machining. Can be punched, stamped, and sawed without chipping or cracking. Requires no aging; orders shipped immediately.*

TENITE

APPEARS in prominent uses in 1934 motor cars, sporting goods, toilet articles, optical supplies, food containers, and many other types of products. Tenite is a superior thermoplastic. It is made of Eastman cellulose acetate, of the same uniform high quality as that used in Eastman safety film. Tenite is ideal for molded products requiring high strength, translucent coloring, smooth finish, accurate dimensions. Write today for samples and information on the molding characteristics of Tenite.

TENNESSEE EASTMAN CORPORATION *(Subsidiary of Eastman Kodak Co.),* **KINGSPORT, TENN.**

ALCOA *Aluminum* makes Rapid Transit ~~Rapider~~..a



The new, revolutionary multi-section car to be used on an "L" run by the New York Rapid Transit Corp.—part of the B. M. T. System. It has 5 sections, with a total capacity of 674 passengers standing and sitting. Weighing only 140,000 lbs. complete, it places *no* added strain on the "L" structure, yet safety is actually *increased* for the light weight Alcoa Aluminum alloy structural parts are thicker and sturdier. Alcoa Aluminum alloys are used throughout. They produce rapid, comfortable, safe acceleration and braking—saving 80,000 lbs. of useless deadweight over heavier construction materials. This multi-section car will make the present 101-minute round trip in 75 minutes, yet will cost less to operate.

IN its never-ending search for safer, swifter, service, the community transit industry is turning, as is all transportation, to the light, strong alloys of Alcoa Aluminum. Eliminating tons of needless weight, yet actually making structural parts thicker, sturdier, *safer;* providing smoother acceleration and braking, higher speeds with lower power and maintenance costs—Alcoa Aluminum is proving itself the ideal metal for all transportation. And that includes railroad cars, elevators, truck bodies, mine cars—every case of mass in motion.

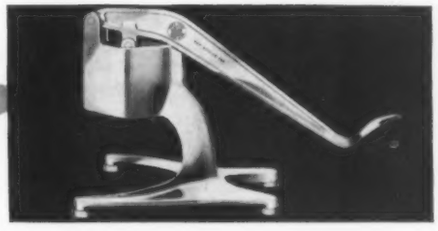
ALCOA ALUMINUM

THROUGHOUT industry, Alcoa Aluminum brings efficiency to production, salability to the product. Lighter in weight, yet strong as structural steel—non-contaminating, non-magnetic, high in heat and electrical conductivity, it meets the requirements of every type of plant equipment. It makes products lighter, more attractive, too. Even in paint, Alcoa Aluminum as a pigment protects plant surfaces from smoke, rust, weathering, acid fumes; brightens up interiors.

We'll be glad to show you how Alcoa Aluminum can help in your business—also how to use, form or handle this modern metal. Address, ALUMINUM COMPANY *of* AMERICA; 1893 Gulf Building, PITTSBURGH, PENNSYLVANIA.

PIPES THAT GROW OLD GRACEFULLY—With metal parts of ALCOA Aluminum, pipes attain the mellowness of age with the inviting cleanliness with which they started out. For ALCOA Aluminum is easy to keep clean; is not attacked by compounds distilled from tobacco in the process of smoking.

HEAT: WHERE AND WHEN YOU WANT IT—Made of ALCOA Aluminum, this portable heater is light in weight, easy to move from room to room. It's lastingly attractive; ALCOA Aluminum's high, even heat conductivity increases its efficiency and eliminates "hot spots."



MAKING LITTLE ONES OUT OF BIG ONES—This ice and ice-cube crusher, made of ALCOA Aluminum, is sturdy and strong enough to do the job—yet it is light enough for even a child to operate with ease. And let's not forget its attractive appearance, that *stays* attractive.

NRA

ALCOA ALUMINUM

A NATION-WIDE RUST-PROOFING SERVICE . .

PARKERIZING SERVICE PLANTS

BALTIMORE, MD.	Federal Tin Company, Inc. Parkerizing Dept. Charles and Barre Streets
BOSTON, MASS.	Rust-Proofing & Metal Finishing Corp. Commercial Ave. and Binney St. Cambridge A.
BUFFALO, N. Y.	Parker Rust-Proof Co. of Buffalo, Inc. 1095 Niagara St.
CANTON, OHIO	G. C. Reiter
CHICAGO, ILL.	Western Rust-Proof Co. 2139 Walnut St.
CINCINNATI, O.	The Stolle Corporation 227-241 W. McMicken
CLEVELAND, O.	Parker Rust-Proof Co. of Cleveland 2617 E. 76th St.
DAYTON, OHIO	Dayton Rust-Proofing Co. 736 N. Main St.
DETROIT, MICH.	2177 East Milwaukee Ave.
EVANSVILLE, IND.	Evansville Plating Works
KANSAS CITY, MO.	Bar-Rusto Plating Corp. 1808 Locust Street
LOS ANGELES, CAL.	Los Angeles Rust-Proofing Company 8141 So. Alameda St.
LOUISVILLE, KY.	Republic Welding Co., Inc. 305 College St.
NEW YORK	Pyrene Manufacturing Co. 560 Belmont Ave., Newark, N. J.
PHILADELPHIA, PA.	Philadelphia Rust-Proof Co. 3229 Frankford Ave.
PITTSBURGH, PA.	Pittsburgh Electro Galvanizing Co. 5th St. and Penna. R. R., Sharpsburg
ROCKFORD, ILL.	Barber-Colman Company
ST. LOUIS, MO.	Mid-West Rust-Proof Co. 3665-7 Market St.
SAN FRANCISCO, CALIF.	Best & Company 2006 Clement Ave., Alameda
TORONTO, ONT.	Fairgrieve & Son 50 Dovercourt Road
TORRINGTON, CONN.	Turner & Seymour Company Parkerizing Department
WAYNESBORO, PA.	Landis Engineering & Mfg. Co., Inc.

Affiliated Foreign Companies:

LONDON, ENGLAND	The Pyrene Company, Limited Great West Road, Brentford
PARIS, FRANCE	Societe Continentale Parker 42 Rue Chance-Milly, Clichy, (Seine)
FRANKFURT, GERMANY	Metallgesellschaft A. G. Bockenheimer Anlage 45
SYDNEY, AUSTRALIA	Parkerizing, Bonderizing, Rust-Proofing, Ltd. Barrack House, 16 Barrack St.
TOKYO, JAPAN	Nihon Parkerizing Kabushiki Kaisha No. 6 Mitsubiski 12 Bldg. Marunouchi, Kojimachi-ku

Parker literature summarizes the findings of the Parker research staff. It describes their more important findings in 17 years of research, supported by extensive practical experience in rust-proofing and finish improvement of iron and steel products in all industries. Copies will be sent on request to interested technical men and manufacturers.

EVERY manufacturer located in the industrial areas of the country is within a few hours of Parkerizing Jobbing Service.

For the manufacturer whose rust-proofing requirements may not be large or continuous, local service is available, making it convenient to provide the added protection and increased sales value of Parkerizing.

Every local service plant is completely equipped to handle the type of material produced in the surrounding territory, and the process will be applied by experts in finishing iron and steel by Parker Processes.

Competent finishing engineers in each plant are prepared to dig into metal finishing problems, and frequently are able to suggest economies in metal finishing operations.

Write your nearest service plant, or direct to

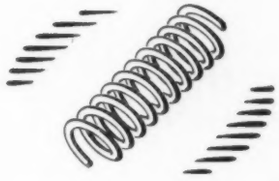
PARKER RUST-PROOF COMPANY
2179 East Milwaukee Avenue Detroit, Michigan

PARKER
RUST-PROOFING
processes
BONDERIZING
PARKERIZING

...and now

BERYLLIUM-COPPER

sheets—wire—rods—tubes—forgings



A heat treated Beryllium-Copper coil spring withstood 10,000,000 cycles of deflection without indication of failure—an illustration of the remarkable fatigue limit values obtainable in this alloy.

BERYLLIUM-COPPER is a relatively new alloy being produced commercially by The American Brass Company.

The most notable characteristic of the alloy is the remarkable improvement in physical properties which can be brought about by heat treatment. In the annealed condition, Anaconda Beryllium-Copper wire, for instance, has a tensile strength of about 74,000 p.s.i. and by a correctly selected heat treatment, this tensile strength may be increased to any desired value up to 181,000 p.s.i. Similar increases are achieved in hardness and fatigue limit.

Whether annealed or cold worked, Anaconda Beryllium-Copper can be fabricated by usual methods, after which finished parts may be physically improved by heat treatment.

A copy of Anaconda publication B-21 describing this alloy in more detail and giving general heat treating instructions will be sent upon request.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury, Connecticut

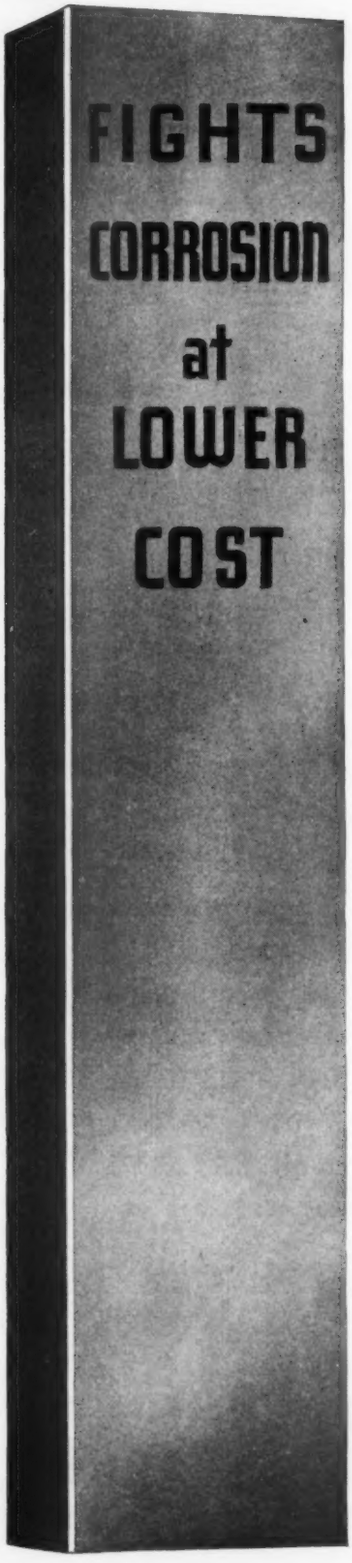
Offices and Agencies in Principal Cities

ANACONDA
from mine to consumer

Canadian Mill: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.

ANACONDA COPPER AND BRASS

USS PLYKROME



● Here at last is an effective steel for combating corrosion at low cost. For Plykrome costs only half as much as solid Stainless Steel, yet it is just as effective in any application in which corrosion resistance is required only on one side.

Plykrome is thoroughly tested. Its patented method of production precludes the possibility of any separation of the Stainless Steel veneer from the base plate.

Plykrome may be fabricated by any of the usual methods without special equipment.

For further information and advice on the application of Plykrome to specific installations, write to the Illinois Steel Company.

Illinois Steel Company

208 S. LA SALLE ST., CHICAGO, ILL.

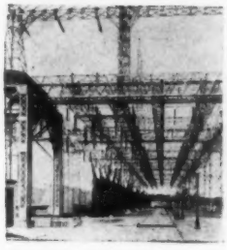
SUBSIDIARY OF
UNITED STATES STEEL CORPORATION

U S S CHROMIUM-NICKEL ALLOY STEELS ARE PRODUCED UNDER LICENSES OF THE CHEMICAL FOUNDATION, INC., NEW YORK, AND FRIED KRUPP A. G. OF GERMANY

NICKEL...

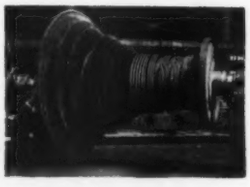
POINTS THE WAY TO GREATER ECONOMIES IN LIGHT, HEAT AND POWER PRODUCTION

THE insistent demand for lower costs forces the power plant engineer to push metals and machines to the limit—to subject them to higher temperatures,



higher pressures, higher speeds. Under conditions such as these the ordinary metals will not suffice—recourse must be had to strong, tough alloys or alloys particularly resistant to heat and corrosion.

When nickel is correctly alloyed with other metals a wide range of improved properties is obtained—properties that assure increased resistance to the destructive forces of heat, stress, fatigue, erosion, corrosion, abrasion, wear. By taking advantage of these improved properties, progressive engineers are enabled to design and construct machinery and equipment that is more efficient, more enduring and more economical to operate and maintain.



The alloys containing Nickel embrace a variety of compositions, each carefully determined by exhaustive laboratory and service tests. Wherever equipment is thoroughly modern you are certain to find Nickel Alloy Steels, Nickel Cast Irons, Nickel Bronzes, Stainless Steels, etc., serving a wide variety of purposes. In power plants they are used for rotor blades and shafting; for steam cylinder castings, piston rods, fittings, valves,

bolts; for bearings and packing; for grate bars, meter parts, and for scores of electrical, rotating and sliding applications.

Their use, however, is by no means confined to these industries. Alloys containing Nickel are widely employed today in every industry where machines require metals of greater endurance and greater dependability. And when you consider all the advantages of alloying with Nickel, the extra cost is really small in relation to the benefits secured. In many cases only a little Nickel (from ½% to 5%) is required to produce definitely superior mechanical properties.

Moreover these alloys containing Nickel are easy to secure. They are commercially available *in a variety of compositions* in all important metal consuming centers. If you are planning to build new equipment or modernize the old, our engineers will be glad to advise you concerning the most suitable applications. You may feel free to consult our technical staff at any time regarding your problems.

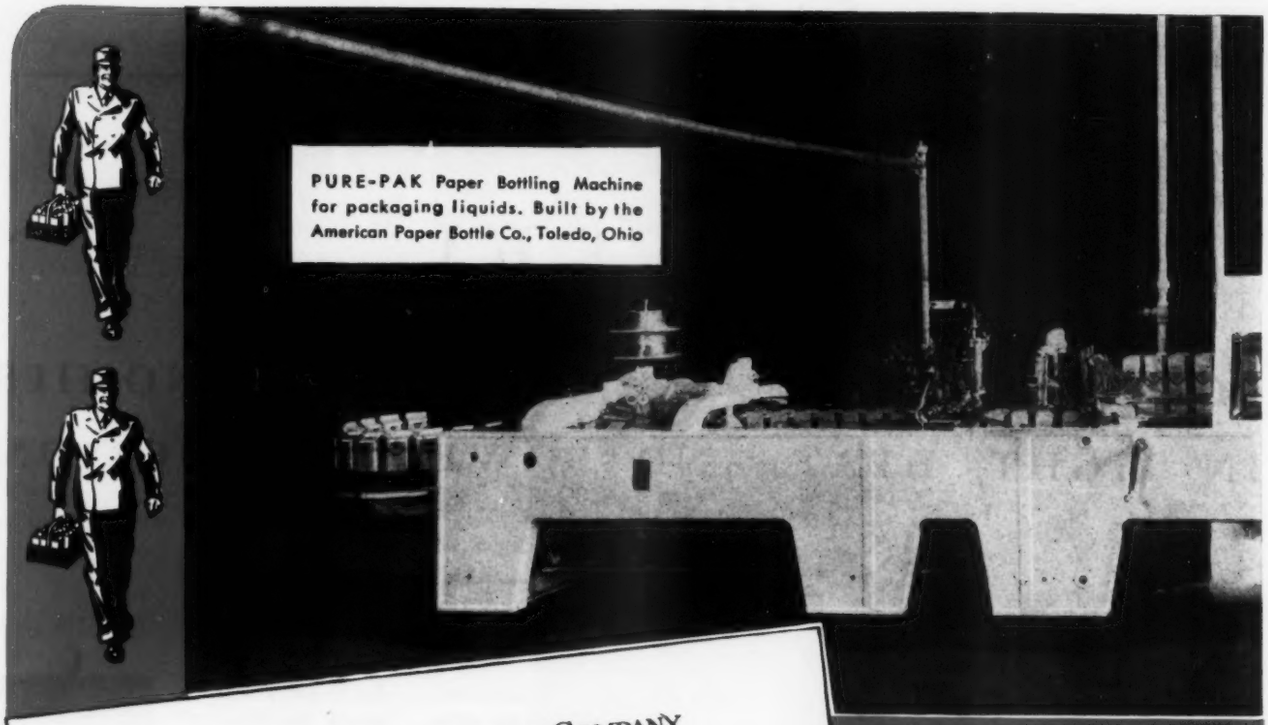
Nickel Alloy Steels

Among the most notable materials in extending the life of machinery are Nickel Alloy Steels. A typical application in the Light, Heat and Power industry is pictured at the left. This Nickel Alloy Steel spindle for 75,000 kw. 1800 R.P.M. turbine is unusually strong, tough and stress-resisting. More and more of this superior material is being used every year in the country's leading industries.

THE INTERNATIONAL NICKEL COMPANY, INC.

Miners, refiners and rollers of Nickel. Sole producers of Monel Metal.

67 Wall Street **New York, N. Y.**



PURE-PAK Paper Bottling Machine for packaging liquids. Built by the American Paper Bottle Co., Toledo, Ohio

THE AMERICAN PAPER BOTTLE COMPANY

931 Brown Avenue
TOLEDO - OHIO

The Dow Chemical Company, September 15, 1933
Midland, Michigan.
Attention - Mr. W. F. Stumpfig

Gentlemen:

Our Cost Accounting Department has just compiled the actual relative cost of parts of our Pure-Pak paper bottle machine which were changed from ordinary materials to Dowmetal. As indicated by the following list the basic cost of Dowmetal was higher but the cost of the finished part was less than when ordinary materials were used because of the great saving in machining time.

Part No.	Name	Material	Cost Material	Cost Labor	Total Cost	Saving in Cost
15305	Spider Cover	Cast Iron	8.30	66.62	74.92	5.35
		Dowmetal	29.04	40.53	69.57	
15313	Spider Cover	Cast Iron	9.05	66.97	76.02	4.92
		Dowmetal	30.10	41.00	71.10	
20998	Slide R. H.	Semi-Steel	.75	7.00	7.75	.06
		Dowmetal	2.69	5.00	7.69	
21026	Arm	Semi-Steel	.83	8.00	8.83	.75
		Dowmetal	2.08	6.00	8.08	
21025	Barrel	Semi-Steel	2.80	41.00	43.80	3.30
		Dowmetal	8.50	32.00	40.50	

Further economies are affected during assembly of the parts due to the very light weight of Dowmetal. In the case of part #15305 and #15313, two men and a crane were necessary to place these parts in position when made of cast iron. When made of Dowmetal one man can easily assemble the parts.

The greatest advantage, however, is gained when the parts are in operation in the Pure-Pak machine. All of these parts move intermittently, starting and stopping 25 times per minute. By the use of Dowmetal a saving of 565 lbs. of moving load per machine is affected, resulting in 14,125 lbs. less load to move per minute than when cast iron was used. This, of course, prolongs the life of the driving mechanism, reduces the power bill and gives quieter and more satisfactory operation. We are more than pleased with the results obtained by the use of Dowmetal.

Yours very truly,

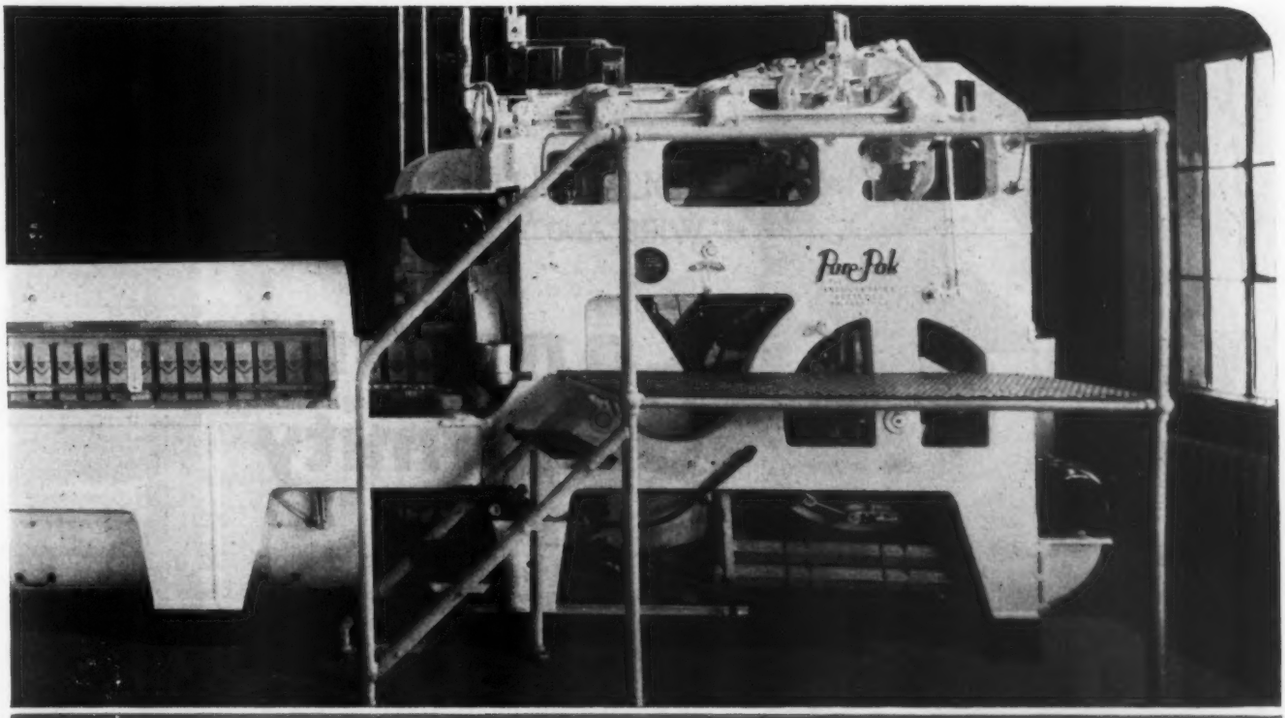
THE AMERICAN PAPER BOTTLE COMPANY

By: H. T. Scott

HTS'DB

Pure-Pak

THE DOW CHEMICAL COMPANY



DOWMETAL REMOVES 14,125 LBS.
Starting load per minute

WRAPPING a quart of milk as easily as a loaf of bread is the achievement of The American Paper Bottle Company of Toledo, Ohio, which bids fair to revolutionize dairy methods. Think of it—no bottles to collect, sort, wash, sterilize; no breakage, no lost bottles.

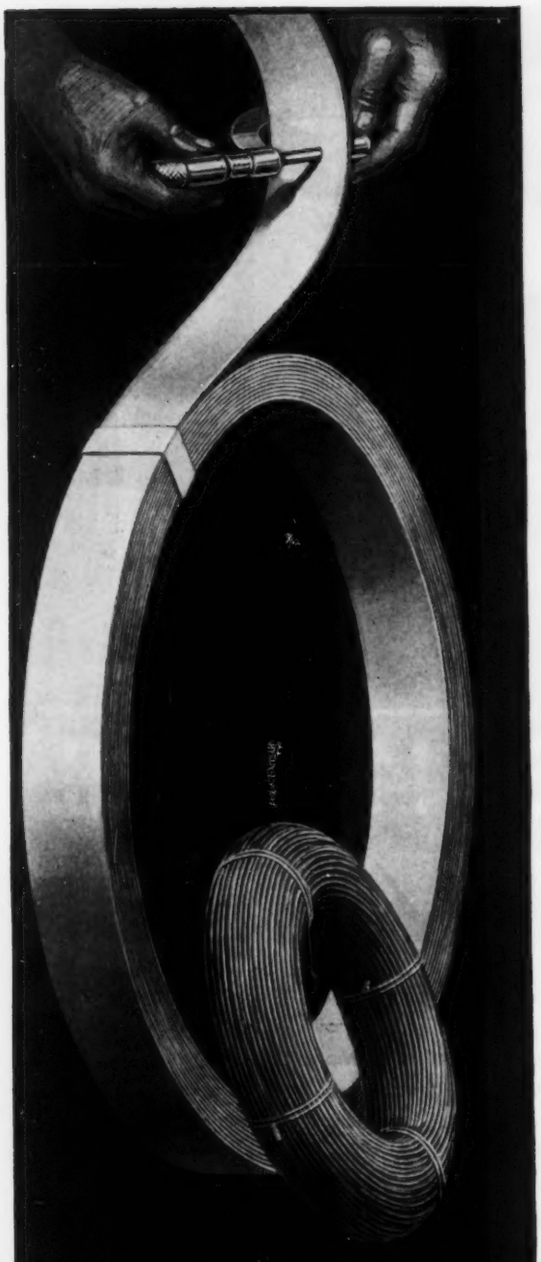
The PURE-PAK Machine as illustrated builds a container, sterilizes it, fills it with milk, and seals it at the rate of 25 per minute. Quarts, pints, and half pints all handle alike, and milk, buttermilk, oils, fruit juices, and other liquids are packaged with equal facility.

Dowmetal plays an important part in the smooth operation of this machine, as well as in its cost. Replacing heavier metals used in earlier models, Dowmetal takes five hundred and sixty-five pounds of dead weight out of moving parts. With all of these parts starting and stopping twenty-five times a minute, Dowmetal eliminates 14,125 pounds of starting load per minute. Moreover the greater efficiency on this job is obtained at an actual saving in the cost of finished parts, as shown by the letter which we reproduce. This easiest of all metals to machine makes possible a saving in machining cost which greatly offsets the higher initial cost of the rough castings.

Those who build machines with rapidly moving parts will secure quieter, smoother operation and longer life by judicious use of lightweight Dowmetal. Dowmetal, lightest of all structural metals, can be sand or die cast, rolled, extruded, forged and welded by methods common to industry. Mention your problem. Ask for data.

DOWMETAL
MAGNESIUM ALLOYS

• DOWMETAL DIVISION • MIDLAND, MICHIGAN



USS STAINLESS and Heat Resisting ALLOY STEELS

CHROMIUM-ALLOY STEELS *Ferritic*	CHROMIUM-NICKEL STEELS *Austenitic*
USS 12	USS 18-8
USS 17	USS 18-12
USS 27	USS 25-12

U S S Chromium-Nickel Alloy Steels are produced under licenses of the Chemical Foundation, Inc., New York; and Fried. Krupp A. G. of Germany.

USS STAINLESS and Heat Resisting ALLOY STEELS

COLD ROLLED STRIP STEEL WIRE AND WIRE PRODUCTS

Constant Uniformity

The strictest of laboratory and shop supervision governs every mill and manufacturing operation in our production and insures constant adherence to specifications. This policy is of special importance in the production of cold rolled strip steel—wire and wire products in stainless and heat-resisting alloy steels.

Regardless of what your fabricating problem may be—whether you need cold rolled strip steel in coils or strips up to 24 inches wide—whether your merchandise calls for cold drawn wire in coils or straightened and cut lengths, you will find an exact and economical solution to your problem here.

Our engineers will gladly assist you in determining which of the six U S S compositions is best suited to your needs. Upon request we will mail you an interesting and comprehensive booklet on U S S Chromium and Chromium-Nickel Alloy Steels.

1831 MORE THAN 100 YEARS of PROGRESS IN WIRE MAKING **1933**

AMERICAN STEEL & WIRE COMPANY

208 South La Salle Street, Chicago
94 Grove Street, Worcester

SUBSIDIARY OF UNITED STATES STEEL CORPORATION
AND ALL PRINCIPAL CITIES

Empire State Bldg., New York
First National Bank Bldg., Baltimore

Pacific Coast Distributors: Columbia Steel Company, Russ Building, San Francisco
Export Distributors: United States Steel Products Company, New York

Henry Dreyfuss says...

"Design is a modern salesman, utilizing new materials, forms, colors, and ideas to produce increased returns for both manufacturer and retailer . . ."

MANUFACTURERS are rapidly realizing that an appeal to the eye through adding beauty of design to intrinsic merit is good salesmanship. When buyers like the fine appearance of your appliance or device the battle for orders is more than half won.

An example of what may be done with a strictly utility appliance to lift it above competition is provided by the Associated Merchandising Corporation's "Laundress" Washing Machine recently redesigned by Mr. Dreyfuss. This new design is characterized by simplicity of line and form, and the elimination of exposed gadgets or sharp corners that catch onto clothing and also accumulate dirt. The pleasing and appropriate black and cream color scheme is accented by the ball shaped control knobs of rich red Bakelite Molded, which will retain color and finish for the life of the machine.

In the present period of widespread redesigning to increase sales, Industrial Designers are almost daily discovering new uses for Bakelite Materials. In products of every description it is possible to improve appearance or performance, and quite frequently reduce cost, through the use of Bakelite Materials. We would be glad to discuss redesign problems with you, and also to mail copy of booklet 5M, "Bakelite Molded."

Henry Dreyfuss, 580 Fifth Avenue, New York, is recognized as an outstanding leader among the artists who are devoting their talents to Product Design. His work includes the designing of a wide range of products including business machines, stoves, hardware, refrigerators, silverware, clocks, watches, airplanes, and many other products.

BAKELITE CORPORATION, 247 Park Avenue, New York, N.Y. . . . . 43 East Ohio Street, Chicago, Ill.
BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario, Canada

BAKELITE

REGISTERED U. S. PAT. OFF.

"The registered trade marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

THE MATERIAL OF A THOUSAND USES

ALLEN

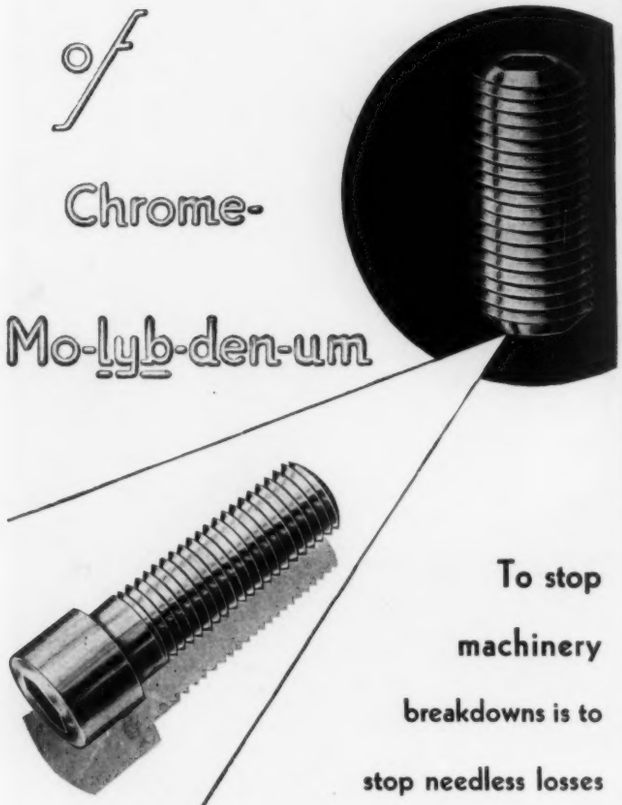
TRI-MARK TRADE MARK

HOLLOW SCREWS

of

Chrome-

Mo-lyb-den-um



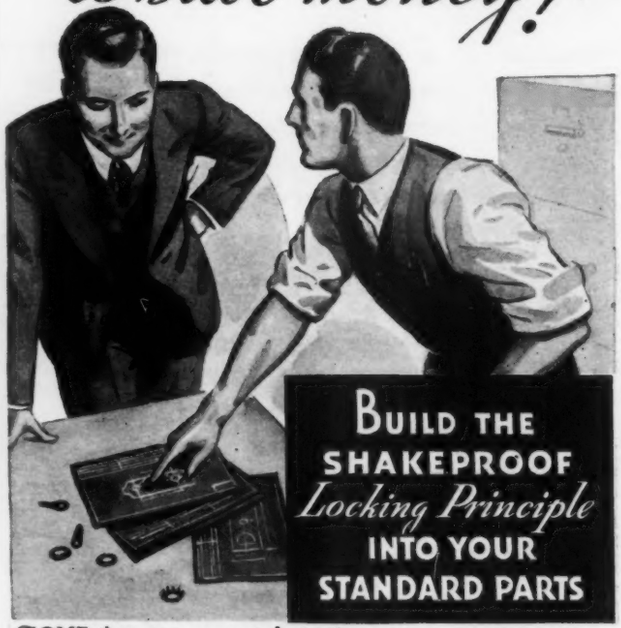
To stop machinery breakdowns is to stop needless losses on close-figured jobs

PROFIT-making machinery runs fast; production tie-ups are profit break-ups; interruptions don't pay because customers won't pay ENOUGH. Continuity of operation comes first in any consideration of Hollow Screws. It's first consideration, too, in making Allen screws of CHROME-MOLYBDENUM. . . Engineers and production men specify Allen screws of *this steel*—heat-treated, cold-worked by Allen processes into products of steadfast performance. » » »

THE ALLEN MFG. COMPANY
HARTFORD, CONN. U. S. A.

SHAKEPROOF

FOUND! *a new way to save money!*



BUILD THE SHAKEPROOF *Locking Principle* INTO YOUR STANDARD PARTS

SOME time ago a smart designing engineer discovered that he could save money for his firm and provide better performance for his product by incorporating the Shakeproof locking principle into certain standard parts. Since then several leading manufacturers have also taken advantage of this practical idea.

Possibly you have a part on your product where this money-saving method can be employed. If you have, you should consult Shakeproof's engineers immediately. It saves the purchase of separate lock washers because the twisted teeth are built right into the part. Each tooth bites into both nut and work and there is no possible movement of the part regardless of how great is the vibration.

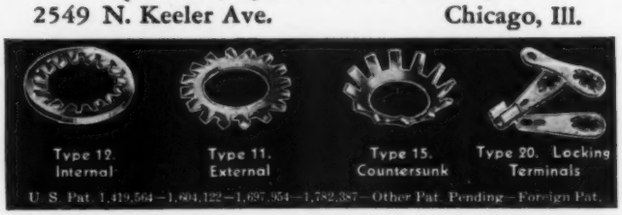
Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

Be sure to look into this new method for cutting costs—look over your product to see where it can be used and then write for a Shakeproof engineer to discuss the matter with you personally. No obligation, of course, so write us today!

SHAKEPROOF
Lock Washer Company

{Division of Illinois Tool Works}

2549 N. Keeler Ave. Chicago, Ill.



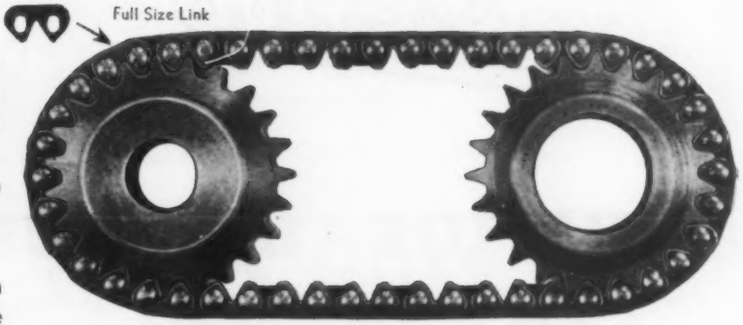
U. S. Pat. 1,419,564—1,604,122—1,697,954—1,782,387—Other Pat. Pending—Foreign Pat.

MIDGET POSITIVE DRIVES

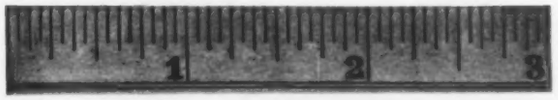
3/16" PITCH

Built By LINK-BELT

Full Size Link



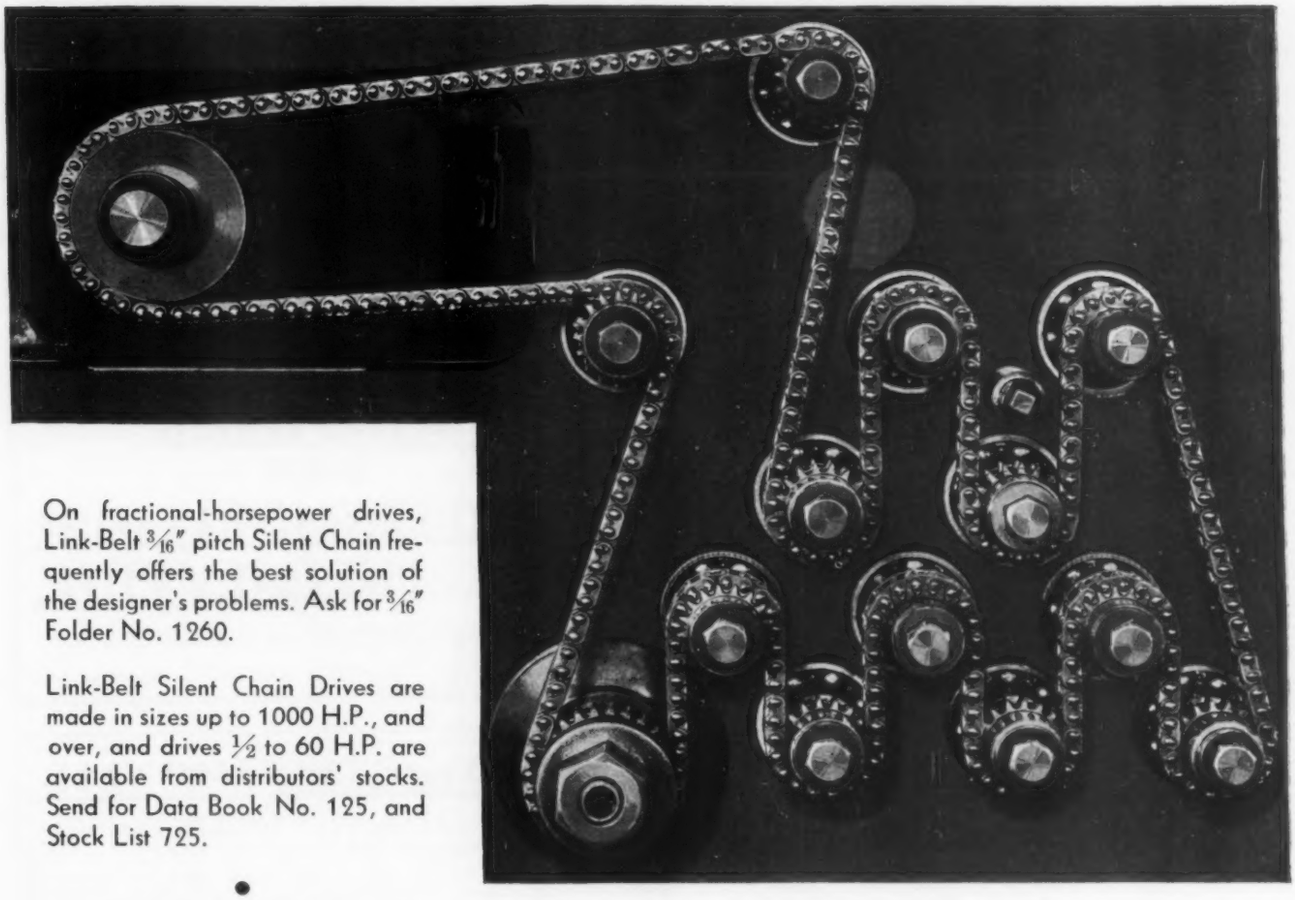
Actual size of a 3/16" pitch Silent Chain Drive.



FRACTIONAL-HORSEPOWER drives can be made more efficient and dependable through the use of Link-Belt 3/16" pitch Silent Chain.

It is furnished in Middle Guide, Side Flanged, or Duplex type, the latter being for use where reverse direction is desired on some shaft or shafts, or where adjustment features are required.

A 4-wheel drive employing Duplex type Link-Belt 3/16" pitch Silent Chain; 12 wheels are 1¼" diam., having 21 teeth; all shafts mounted on a plate but 18" long by 12" high.



On fractional-horsepower drives, Link-Belt 3/16" pitch Silent Chain frequently offers the best solution of the designer's problems. Ask for 3/16" Folder No. 1260.

Link-Belt Silent Chain Drives are made in sizes up to 1000 H.P., and over, and drives ½ to 60 H.P. are available from distributors' stocks. Send for Data Book No. 125, and Stock List 725.

•

LINK-BELT COMPANY

Leading manufacturers of Positive Power Transmitting Equipment
Indianapolis, Dodge Plant, 519 N. Holmes Ave.; Ewart Plant, 220 S. Belmont Ave.; Chicago Plant, 300 W. Pershing Rd.; Caldwell-Moore Plant, 2410 W. 18th St.; Philadelphia Plant, 2045 W. Hunting Park Ave.; San Francisco Plant, 400 Paul Ave.; Toronto Plant, Eastern Ave. and Leslie St.
Offices in All Principal Cities

Link-Belt Positive Drives Include:

Silent Chain Drives
Silverlink Roller Chain Drives
P. I. V. Gear (Positive, Infinitely Variable Speed Transmission)
Worm Gear Speed Reducers
Herringbone Gear Speed Reducers
Chain Drives of all types (Malleable Iron, Promal or Steel)
Herringbone Gears
Flexible Couplings

4752

LINK-BELT Positive DRIVES

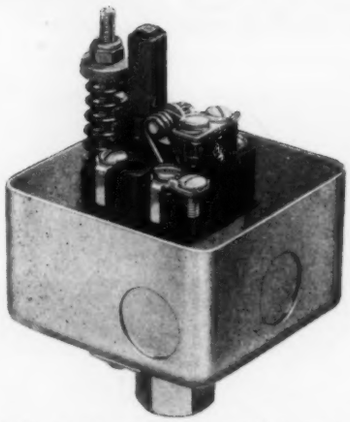
(See Our Exhibit at A Century of Progress, Chicago)

Elastic Stop

The lock nut with the fibre collar

Reg. Trade Mark U. S. & Foreign Patents.

THE IDEAL ADJUSTMENT NUT



Square D pressure switch using brass No. 10/32 Elastic Stop Nut.

The Square D Company has standardized on Elastic Stop Nuts for their pressure switches because they maintain the spring at the calibrated adjustment. In spite of the vibration caused by the snap action on this type of switch, Elastic Stop Nuts stay at the fixed position.

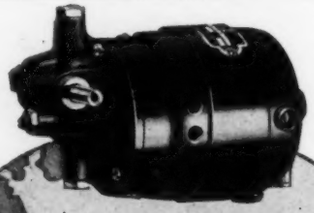
Whether for adjustment applications of instruments or heavy machinery, Elastic Stop Nuts work equally well. This lock nut can be drawn to the desired position along the bolt threads and will remain there. Even should the seating surface be withdrawn, the Elastic Stop Nut will stay at the position to which it is adjusted, as it locks to the bolt independently.

Sizes available from No. 3/48 up to 3".

Write for catalogue.

ELASTIC STOP NUT DIVISION
A. G. A. COMPANY

ELIZABETH **NEW JERSEY**



DUMORE—
The World's Finest Small Motors

In every detail of their construction Dumore Fractional Horse Power Universal Motors are the finest available. They can be supplied in any size up to ¾ H. P. and can be adapted to a wide variety of applications. Regardless of what your requirements may be, ask for technical data regarding the construction and performance of Dumore motors before deciding.

DUMORE COMPANY
99 Sixteenth St., Racine, Wis.

DUMORE
FRACTIONAL HORSEPOWER
MOTORS

Get in touch with AMERICA'S LEADING SUPPLY SOURCE *for* PLASTIC MOLDED PARTS

SCRANTON FOR 50 YEARS SB BRAND BUTTON

AMERICAN RECORD CORPORATION

Molded Products Division SCRANTON, PA.

NEW YORK CHICAGO DETROIT CLEVELAND HOLLYWOOD, CAL.

Sixth Year TESTIMONIAL

"Our business with ROXALIN has been based entirely on their ability to produce materials suitable for our specific requirements. During this long period we have, of course, had full opportunity to test the durability, flexibility and adhesion of their lacquers and there has never been any occasion for complaints."

ROXALIN FLEXIBLE LACQUER CO., INC.
35-40 Thirty-Sixth Street Long Island City, N. Y.

Multiple V-Belt Drive Announcement

ALLIS-CHALMERS Manufacturing Company, of Milwaukee, Wisconsin, announces that licenses under United States Letters Patent No. 1,662,511 relating to power transmitting mechanism, commonly known as Multiple V-Belt Drive, have been granted to the following belt and sheave manufacturers:

The American Pulley Company - - - - - - Philadelphia, Pa.
The Dayton Rubber Manufacturing Company - - - Dayton, O.
R. & J. Dick Co., Inc. - - - - - - - - - - Passaic, N. J.
Dodge Manufacturing Corporation - - - - - Mishawaka, Ind.
L. H. Gilmer Company - - - - - - Tacony, Philadelphia, Pa.
Goldens' Foundry & Machine Company - - - - Columbus, Ga.
The B. F. Goodrich Rubber Company - - - - - - Akron, O.
The Goodyear Tire & Rubber Company, Inc. - - - Akron, O.
W. A. Jones Foundry & Machine Company - - Chicago, Ill.
The Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc. - - - - - - Passaic, N. J.
The Medart Company - - - - - - - - St. Louis, Mo.
The Ohio Valley Pulley Works - - - - - - Maysville, Ky.
Pyott Foundry & Machine Company - - - - - Chicago, Ill.
Rockwood Manufacturing Company - - - - Indianapolis, Ind.
T. B. Wood's Sons Company - - - - - - Chambersburg, Pa.
Worthington Pump and Machinery Corporation - Harrison, N. J.

Allis-Chalmers Manufacturing Company

Milwaukee, Wisconsin

WE SPECIALIZE IN EVERYTHING!

PREPOSTEROUS! But how else can we define our unique service? ¶ With available facilities unsurpassed, we believe, by those of most large companies, we are in a position to handle every phase of a wide range of undertakings. ¶ In addition to up-to-date shops for production in wood and metal, we have well equipped laboratories for research and testing, as well as reliable contacts in many other fields. ¶ Our customers include such representative companies as Thomas A. Edison, Inc., Standard Brands Incorporated, and E. R. Squibb & Sons.

CALIBRON PRODUCTS

INCORPORATED

West Orange CALIBRON New Jersey

CB

It is simple—easy—to make BLACK AND WHITE positive prints directly from your originals—without the use of a negative! The NEW No. 2836 Motor-Driven BW DEVELOPING MACHINE can be used by anyone having blue-printing equipment. Just introduce exposed paper into this machine—it comes out as a fully developed positive—no washing or drying. Machine is quality product throughout—yet sells for amazingly low price of $57.50 (slightly higher west of Rockies). Write for complete information.

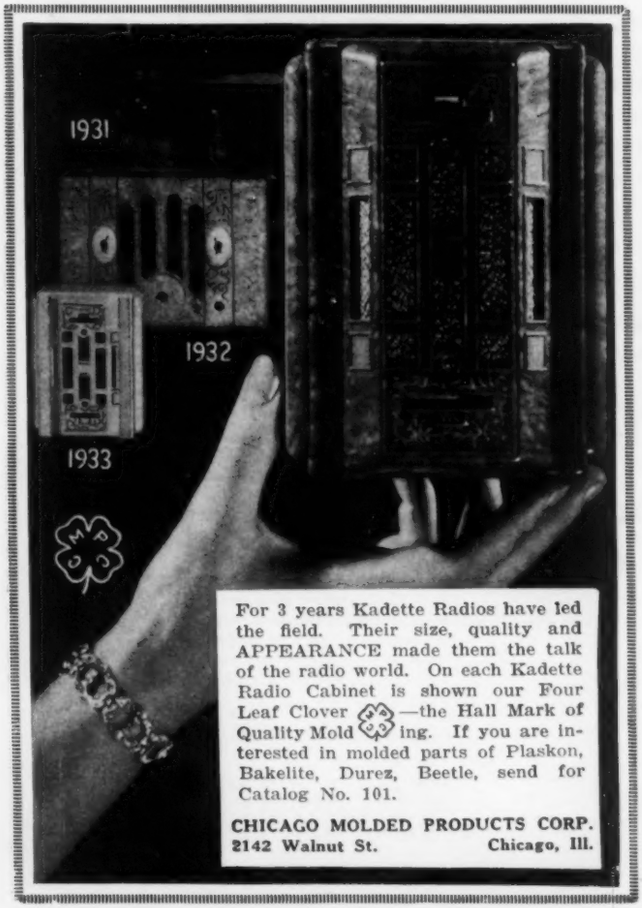
Charles Bruning Company, Inc.
Since 1899

Home Office
102 Reade Street
New York City

Chicago Office
445 Plymouth Court
Chicago

Boston Detroit Los Angeles Newark
Pittsburgh San Francisco St. Louis

BRUNING



For 3 years Kadette Radios have led the field. Their size, quality and APPEARANCE made them the talk of the radio world. On each Kadette Radio Cabinet is shown our Four Leaf Clover —the Hall Mark of Quality Mold ing. If you are interested in molded parts of Plaskon, Bakelite, Durez, Beetle, send for Catalog No. 101.

CHICAGO MOLDED PRODUCTS CORP.
2142 Walnut St. Chicago, Ill.

You Need This Expert Help On Bearing Specifications

We are aiding many machinery manufacturers and engineers in the making of bearing specifications that reduce cost and enhance performance. It costs you nothing to find out what we can do for you. Ask us.

THE BUNTING BRASS & BRONZE COMPANY, Toledo, Ohio

BRANCHES and WAREHOUSES
New York, Brooklyn, Chicago, Boston, Detroit, Cleveland, Philadelphia, Dallas, Kansas City, Los Angeles, Seattle, San Francisco. Export Office: Toledo, Ohio

BUNTING
QUALITY
PHOSPHOR BRONZE
BUSHING BEARINGS
PATENTED

MIDGET MOTORS
TWO-POLE UNIDIRECTIONAL TYPE

For applications requiring small, high-torque, A. C. motors.

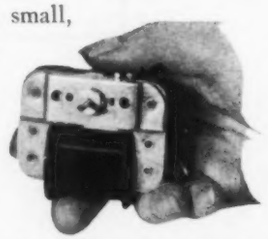
Sizes, 1/3000 to 1/125 h.p.

Speeds, 1500 and 2400 r.p.m.

Torque range, 1/50 to 1/4 lb. in.

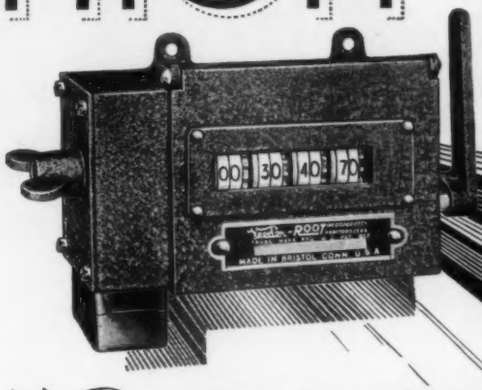
Power consumption, 10 to 50 watts.

Write Dept. PE-12 for complete data.



BARBER-COLMAN COMPANY
Rockford, Ill., U. S. A.

HIGH SPOTS IN Profit-Planning



HOURLY PRODUCTION TOTALS AT INDIVIDUAL MACHINES

COST PER PIECE UNDER THE N.R.A. WAGE RATES

SAVINGS POSSIBLE BY IMPROVED OPERATOR EFFICIENCY

SAVINGS THROUGH ELIMINATING OVER-RUNS AND UNDER-RUNS

Veeder-Root COUNTERS

make profits materialize from *planned operating*, not hopeful speculating

Ask about applications

BUILDERS OF COUNTERS

Veeder-Root INCORPORATED HARTFORD, CONN.

FOR EVERY PURPOSE

The Foundation of Modern Manufacturing Success is

LEADERSHIP IN Product Engineering

PROFESSIONAL SERVICES

FOSTER D. SNELL, INC.

Chemists—Engineers

A technical organization offering complete consulting, research operating and management service.

305 Washington Street Brooklyn, N. Y.

GEORGE W. WALKER

Industrial Stylist

New Center Building, Detroit

MERCOID AUTOMATIC CONTROLS

USED THE WORLD OVER — MERCOID CONTROL

ARE EQUIPPED *with*

CHACE THERMOSTATIC BIMETAL

"It Bends with the Heat"

Since 1928 ››

Thousands upon thousands of Chace Bimetal formed units have been supplied to meet Mercoid's rigid specifications—not one Chace unit has ever been rejected. Accuracy, consistent uniformity and dependable operation under all conditions are the results of strict adherence to known, proven engineering and plant practices. 1200° F. without distortion. Consult our Eng. Dept. regarding your specific problem.

SHEETS, STRIPS OR FORMED

W. M. CHACE VALVE CO.

1607 Beard Avenue . . . Detroit Mich

INDEX TO ADVERTISERS

Allen Mfg. Co. 26
Allis Chalmers Mfg. Co. 29
Aluminum Co. of America 16-17
American Brass Co. 19
American Gas Accumulator Co. 28
American Record Corp. 28
American Steel & Wire Co. 24

Bakelite Corp. 25
Barber Colman Co. 30
Bausch & Lomb Optical Co. 6
Bruning Co. Inc., Chas. 30
Bunting Brass & Bronze Co. 30

Calibron Products Inc. 30
Carnegie Steel Co. 14
Carpenter Steel Co. 10-11
Chace Valve Co., W. M. 31
Chicago Molded Products Corp. 30
Cutler Hammer, Inc. ..... 3rd Cover

Dayton Rubber Co. 9
Dow Chemical Co. 22-23
Dumore Co. 28

Garlock Packing Co. 4
General Electric Co. 13

Holtzer-Cabot Co. 32
Hyatt Roller Bearing Co. 8

Illinois Steel Co. 20
Imperial Tracing Cloth 12
International Nickel Co., Inc. 21

Link Belt Co. 27

New Departure Mfg. Co. 5
New Jersey Zinc Co. ..... 4th Cover

Parker Rust Proof Co. 18
Professional Services 31

Roxalin Flexible Lacquer Co. 28

Scovill Mfg. Co. 3
Shakeproof Lock Washer Co. 26

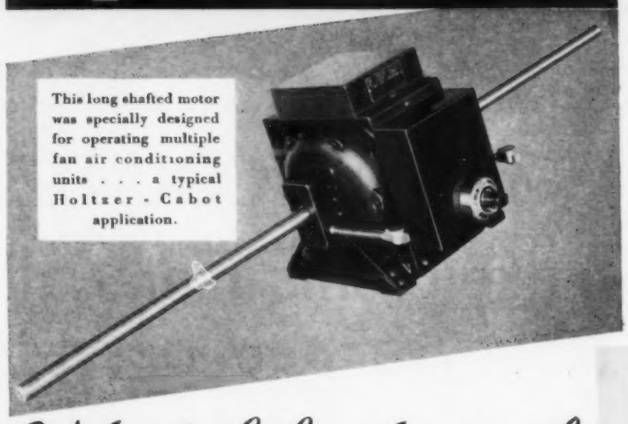
Taylor Instrument Co. ..... 2nd Cover
Tennessee Eastman Corp. 15

Veeder-Root, Inc. 31

Westinghouse Elec. & Mfg. Co. 7

Design Engineers!

3 frank questions



This long shafted motor was specially designed for operating multiple fan air conditioning units . . . a typical Holtzer-Cabot application.

We'd like to ask..

1 Are you having any trouble with motor noises?

2 Does your present motor in any way restrict the utmost efficiency of your product?

3 Have you sacrificed attractiveness of design merely to accommodate your product to some standard built motor?

If so . . . we'd like an opportunity to sit down and talk things over. For over forty years, engineers of The Holtzer-Cabot Electric Company have been making custom built motors to meet all types of fractional horsepower application. For example, the long shafted air conditioning motor illustrated above.

Custom built motors quickly pay for themselves in lowered maintenance costs. Moreover a "built for the job" motor can emphasize any desired need. In designing your next season's model, why not let us show you what we can do? You may find our suggestions very much worthwhile.

The HOLTZER-CABOT ELECTRIC CO.

125 AMORY STREET

BOSTON, MASSACHUSETTS

Fractional Horsepower Motor Specialists